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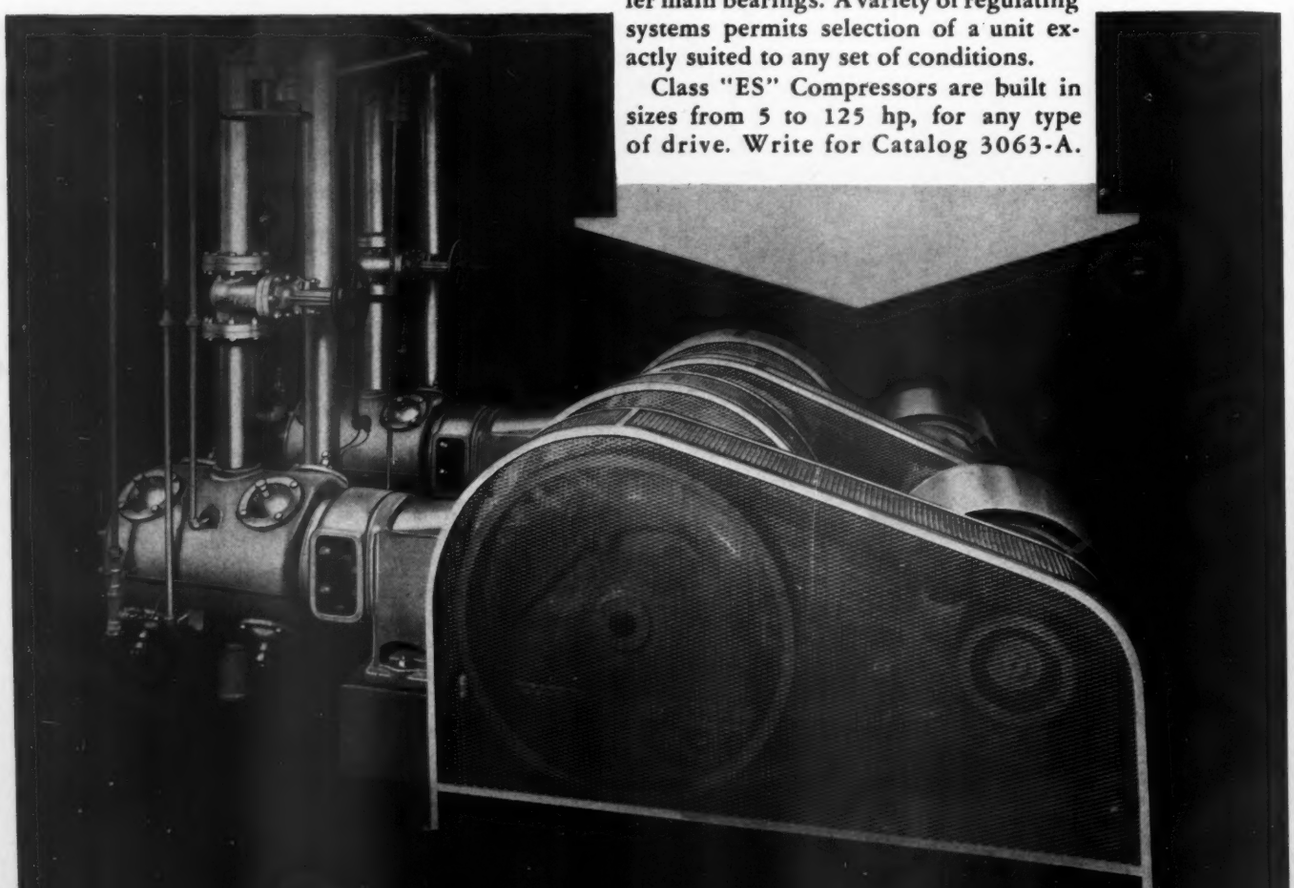

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ON THE COVER

SMALL riveting hammers, weighing as little as 2¾ pounds, are extensively used in various branches of industry for driving aluminum, duralumin, and soft-iron rivets up to 5/32 inch in diameter. Three types of grip are available, and the power can be readily regulated by the operator to meet the requirements of the work being done. These tools are employed in airplane manufacture and maintenance work, and in the fabrication of trucks, buses, metal furniture, and electrical and radio equipment. When supplied with the proper chisel, they can be used for light chipping, scaling, or calking. Our cover picture shows an Ingersoll-Rand hammer driving 5/32-inch aluminum rivets during the overhauling of a transport airplane.

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IN THIS ISSUE

MUCH of our cast-iron pipe, especially that of the larger sizes, is still made by methods that were introduced nearly a century ago. Its manufacture is an interesting branch of the founder's art in which the skill of workmen controls the quality of the product. Mechanical equipment has taken over most of the heavy handling tasks and increased the output per man, but it has so far failed to supplant some of the picturesque practices that are described in our leading article.

•

IT HAS been amply demonstrated that organized safety work reduces accidents. The metal-mining industry is keenly safety conscious and has, through systematic, persevering efforts, reduced hazards to such a great extent that miners in many properties are less liable to be injured at their work than they are at home. *Safety in Mine Drilling* outlines an experienced safety engineer's recommendations for handling drills and allied equipment underground.

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THE general manager of the Frazier-Davis Construction Company's operations on the Delaware Aqueduct takes us underground to explain how a link in New York's future water-supply system is being built.

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1940 INDEX

A COPY of the index for our 1940 issues is available to anyone requesting it.

Compressed Air Magazine

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CAST-IRON PIPE

C. H. Vivian

CASTING PIPE

The picture above shows a 36-inch pipe being poured. At the right is a general view of the pit, with flasks along the two side walls, in which pipes from 14 to 60 inches in diameter are cast.

BENEATH the streets of every American city is a network of pipes that supplies water and gas to houses, factories, and office buildings and takes sewage away from them. Most of this piping is of cast iron, a material that has been preferred for these purposes ever since it was first made available and that is still holding its own against the competition of more recently introduced products. Cast-iron pipe continues to be widely used because of its outstanding record for long service life and also because its first cost compares favorably with that of any substitute yet offered. The United States is still too young a country to furnish adequate information on the duration of cast-iron pipe. Even in Europe no conclusive data can be obtained, for some of this piping that was laid there nearly four centuries ago continues to function. Most of the replacements that have been made have come about not because of its failure but rather because the growth of cities has required the laying of larger lines.

America leads the world in the use of cast-iron pipe by reason of our supremacy in the field of water supply and sanitation. Our national daily consumption of water amounts to 100 gallons per capita, a quantity that is beyond the comprehension of residents of some of the less progressive countries. We possess 95 per cent of the world's bathtubs; and it takes 45 gallons of water to fill one of average size. To supply our needs, the fifteen principal pipe foundries of the United States operate 22 plants and produce around 1,000,000 tons of piping annually.

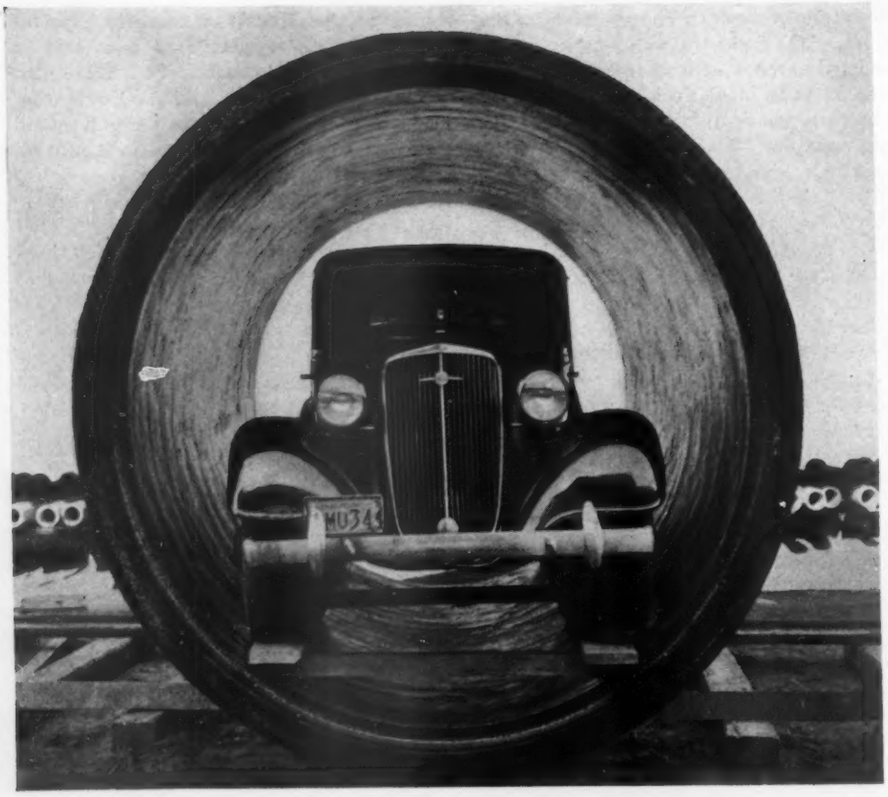
Before cast-iron pipe was known, water was conveyed through connected sections of bored logs. The first iron pipe was probably cast in Germany around 1450, and its manufacture gradually spread throughout western Europe and to England. The industry was slow in getting started in the American colonies, however, and in both New York and Philadelphia the early water-distribution systems were log conduits. The first extensive use of cast-iron pipe was made in Philadelphia in 1817, when 400 feet of it was imported from England. It is generally recognized that the first major casting in this country was done at Weymouth Furnace, near Egg Harbor, N. J., in 1819. The pipe, which ranged in diameter from 1½ to 20 inches, was laid in Philadelphia. The first foundry that engaged exclusively in pipe making was established at Millville, N. J., by David C. Wood in 1825. The business survives today under the name of R. D. Wood Company of Florence, N. J.

The industry was aided by the demand for pipe that followed the introduction of gas lighting. New York ran a line up Broadway from the Battery to Grand Street in 1825. The pipe was ordered from England. The residents had to wait longer than they expected to see their main thoroughfare illuminated because the barque *Mary*, of Bristol, required 68 days to cross the Atlantic. During the 30 years prior to the Civil War, cast-iron pipe for water or gas systems had been laid in Reading and Lancaster, Pa., Richmond and Lynchburg, Va., and St. Louis, Mo. The war cut off imports from England and gave impetus to domestic foundries. Following hostilities, however, the price of pig iron mounted and pipe costs went up to the point where some parts of the East once more resorted to bored logs for conduits. Other substitutes for cast iron also appeared, one of them being stove pipe lined with concrete. It was not satisfactory.

The lean period continued until 1883 and was followed by a decade of prosperity. This was partly the result of an era of water-works building. Leading engineers of the country had discussed the need of additional water-supply and sewage systems at the Philadelphia Centennial Exposition in 1876, and in 1881 the American Water Works Association was formed. The movement was in full swing by 1883, and the demand for pipe that ensued led to the establishment of more plants in the next ten years than had previously been erected in the country. In July, 1893, with another depres-

CAST-IRON JIGSAW PUZZLE

This is a pipe gallery underneath the filters in a municipal water-treatment plant. The pipes were made in the Warren Foundry, and as most of them are of irregular shapes and lengths they come under the heading of special fittings. Assemblies of this sort are laid out to fit into the available space, and the castings are made accordingly.



96-INCH PIPE

Part of an order of 22 pieces recently made by the Warren Foundry. This is believed to be the largest pipe ever cast. Ten of the sections were straight and the twelve others were curved—eight 45° bends and four 90° bends. Each straight pipe was 12 feet 5 inches long, had a wall thickness of 1⅞ inches, and weighed approximately 26,000 pounds. Each of the fittings was somewhat heavier. The pipe is of the bell-and-spigot type and was pit cast. Ordinarily, three ladlefuls of metal were required to complete a pour. The material went to the Borough of Queens in New York City for use in a siphon to carry water to a Government project. Working out a means of transporting the pipe to the point of use was almost as great a problem as was that of casting it. The sections were too large to be shipped by rail, so they were trucked, each one making a load. By direct route the haul would have been about 85 miles; but a circuitous course that added many miles had to be taken. There was not sufficient clearance in the Holland Tunnel to permit using it to cross the Hudson River from New Jersey into New York, so the trucks traveled by way of the George Washington Bridge several miles to the north. Arriving on the New York side they could not go straight across town because the load was too heavy for streets traversing subway lines. Accordingly, a detour was made along the Hudson almost as far north as Yonkers, and then east on the Cross County Highway and south to and across the Triborough Bridge to Queens.

sion starting, there were 108 new water projects active.

The first pipe foundries were along the Atlantic seaboard. Gradually they extended westward and southward. The trend in the present century has been toward the South, with Birmingham as the center of manufacture. The attractions were cheap pig iron and a year-round market. In the northern states it is difficult to lay pipe in the winter months, and foundries, accordingly, experience a slack period. It is being felt less this winter than normally because of the brisk demand for pipe for army training camps and other defense-program undertakings. As freight charges are high on such a heavy product, the plant nearest the point of use generally, but not always, stands the best chance of getting the order. There is no large plant west of Provo, Utah, however, and pipe of large size is sometimes shipped from the eastern to the western coast. The number of foundries in operation today is considerably less than it was a few years ago; but while numerous plants have been closed, others have been expanded.

The first pipes were cast on-side, that is, with the mold lying horizontally. This method produced longitudinal ridges on the outside of the pipe where the two halves of the mold met. The latter were made of green or undried sand; but dried cores were introduced at an early stage. The usual length of pipe was about 3 feet, and this was later increased to 6 and 9 feet. Joints were of the bell-and-spigot type, which was developed by Thomas Simpson in England in 1785 and which is still most used. One end of each pipe length is flared or belled so that the plain end of the adjoining length can be fitted into it. The annular space between the two is then calked. Lead was the original calking material and still serves widely; but wood, cement, and various compounds also are employed.

The first pipes produced in this country were cast of metal taken direct from the charcoal furnaces in which it was obtained from the ore. When anthracite coal became generally available, about 1850, American founders adopted the cupola, which had been in use abroad for some years. In it they remelted pig iron, thereby getting a purer and a better-controlled metal. The same method with improvements is practiced today.

A great forward step in technique was the development, in England, of a vertical casting process, for which patents were issued to D. Y. Stewart in 1846. It was introduced to this country by George Peacock in 1852 at a foundry in West Troy, N. Y., and by 1860 had become more or less standard. Peacock, who had worked in English pipe foundries, was in demand for teaching American workmen the new method. As the name implies, the vertical method consists of pouring the iron into a mold standing on end. It speeded up production and made possible a better pipe because the lighter impurities in the metal rose to the top and could be removed later by cutting off a portion of that end. Vertical casting was almost exclusively employed until a few years ago. Many foundries still use it not only for making pipe of all sizes but also all pipe of large diameter, from about 48 inches upward.

Vertical casting is more generally known as pit casting for the natural reason that pits are provided to facilitate preparing the molds, pouring the metal, and withdrawing the cores. The Scotch accomplished the same end by building their working platforms above the floor level; but this procedure required greater headroom. Former practice was to excavate the pit in the form of a semicircular trench reinforced with masonry walls. At the center of the half-circle was mounted a jib crane on a revolving base. This handled the molds, which were stood on end one after another around the circle, and also performed the services incidental to pouring the metal—removing the cores, and lifting the mold and its contained casting out of the pit. With the advent of overhead-traveling electric cranes, pits became rectangular. Pit casting brought with it the use of dry sand molds, although, as previously mentioned, dry sand cores had been employed with on-side casting.

Centrifugal casting was invented prior to 1915 in Rio de Janeiro by Fernando Arens and Demetri S. deLavaud, the latter obtaining patents on it in most of the important countries of the world. It made its appearance in the United States in 1921. The original process required

metal molds; but a method of casting pipe centrifugally in sand-lined molds was subsequently developed in this country. There are now nine plants in the United States using the centrifugal process, and it is reported that they account for the production of about 75 cer cent of our cast-iron pressure pipe. Centrifugal casting increases the physical strength of the iron and makes possible a thinner wall section, or a product weighing less per foot than pit-cast pipe.

In the early days of the industry there was no general standard for cast-iron pipe in this country. Each of the large cities, such as New York and Philadelphia, had its own standards, and smaller municipalities observed these more or less. In 1902 the New England Water Works Association adopted a standard, and this action was followed by the American Society for Testing Materials, the American Water Works Association, and the American Gas Association. New specifications have now been drawn up by the American Standards Association, and it is expected that they will be generally accepted. These are based on tests and research concerning the thickness of pipe required to withstand not only static water pressure and water hammer but also earth pressure and superloads imposed by trucks or other heavy traffic. Account was also taken of the different methods of laying pipe, such as supporting it on blocks or placing it directly on the trench bottom, of the various depths of earth cover, and whether or not trench backfill was tamped.

In general, there are two classifications of cast-iron pipe: pressure pipe, and nonpressure or soil pipe. The standard length of pit-cast pipe is 12 feet, and that of centrifugally cast pipe is 16 feet. Cast-iron pipe is now made with joints other than the bell-and-spigot type mentioned. One of these is a flexible joint for lines laid in marshy ground or under watercourses where settlement may take place. Flanged joints, which require a gasket connection, are often used for piping inside buildings such as water-purification or sewage-disposal plants, or in other locations where it is readily accessible. Plain-end pipes also serve to some extent, being connected by one or other type of sleeve coupling.

One of the oldest cast-iron pipe manufacturers in the United States is the Warren Foundry & Pipe Corporation. It is one of two companies established prior to the Civil War that are still in operation. In its Phillipsburg, N. J., plant it has been making pit-cast pipe continuously since 1857—for a longer period than any other concern can claim. It is with the Phillipsburg plant that the remainder of this article will deal; but it should be mentioned here that another Warren Foundry plant, situated at Everett, Mass., produces pipe from 4 to 16 inches in diameter by means of the centrifugal casting method. It was constructed in 1929.

The concern was incorporated as the Warren Foundry & Machine Company on March 3, 1856, "for the purpose of carrying on general foundry business, including the casting of stoves, steam engines, mill gearing, and any or all branches of the foundry business." There was no thought at the time of manufacturing pipe. The era was one of railroad expansion in its part of the country. During the preceding four years, the Central Railroad of New Jersey, the Belvidere, Delaware Railroad (now a branch of the Pennsylvania), and the Lehigh Valley Railroad had run lines to or through Phillipsburg. The outlook for general foundry business was promising; and the organizers had in mind especially the making of car wheels. Twenty-five residents of Phillipsburg, of the adjacent City of Easton, Pa., on the opposite side of the Delaware River, and of neighboring sections of New Jersey jointly agreed to subscribe $49,500 to launch the enterprise. The largest subscription was $7,000, and the smallest was $500.

One among the founders, whose name has been perpetuated in another industry, was John L. Reigel. He established the Reigel Paper Corporation, which still operates several mills near Phillipsburg. Mr. Reigel served on the board of managers of the foundry for 36 years. The foundry business was owned locally until 1924, when it was sold to the present ownership and given the corporate name it now bears. As indicative of the success that has attended the enterprise, it is interesting to note that it has shown earnings in all but five of its 85 years. With the exception of 1933, dividends have

OLD CASTING PIT

This semicircular masonry-walled pit dates back approximately 80 years and has been in service that long. In the center is a jib crane that differs but little from the handling equipment used in the country's first pipe foundries. Another one is visible in the left background. This pit is still used for making tubing and small pipe of odd lengths, products for which it seems to be better suited than some of the modern sections of the plant.

edge that have been handed down through succeeding generations. Proof of this is found in the fact that Warren Foundry retains one of its original semicircular casting pits served by a wooden jib crane and supplied with iron from a cupola that is hoary with age. It is used for the production of tubing and odd lengths of small pipe that are turned out in relatively small lots. Some of the company's highest-class work originates there. Efforts to do it as well in modernly equipped sections of the plant have not been satisfactory. In the old pit the work seems to receive that fine touch of the molder's art that is unaccountably lost to some extent when more refined facilities are employed. All standard pipe, however, is made in modernized shops with overhead-traveling electric cranes for handling the work quickly and with all possible mechanical aids that can be used to advantage.

been paid continuously since 1868 and have aggregated $17,000,000.

The site chosen for the plant was an advantageous one, Phillipsburg being at the junction of the Delaware and Lehigh rivers, on the Morris Canal that then extended to tidewater at Jersey City, close to producers of pig iron in eastern Pennsylvania, and only two hours by railroad from both New York and Philadelphia. The original buildings were erected on a 6½-acre plot bordering the tracks of the Central Railroad of New Jersey. Subsequent expansions have extended the holdings until they now occupy a narrow strip 3,100 feet long between the railroad and a paralleling street in the town. Additional ground is owned on the opposite side of the street, and the power house is located there.

The future course of the company was determined in 1857, when it was only a year old. That was a panic year, probably the worst the nation had so far experienced. Early in 1857 two English foundrymen, John Firth and John Ingham, came to Phillipsburg. They knew how to cast pipe vertically. The foundry had been making pipe of small sizes in inclined molds on a modest scale. Firth and Ingham entered into a contract to produce pipe for the company, and immediately began experimenting. By July they were casting 30-inch pipes in dry-sand molds with success. The method was tried on the smaller sizes and worked equally well. Since that time the manufacture of cast-iron pipe has been the foundry's principal business.

Pit casting is an interesting process. Although there have been repeated refinements in procedure and improvements in mechanical handling equipment that have lightened labor, the fundamental practice has changed little in 90 years. The making of good pipe still depends largely upon individual skill and knowl-

MAKING A PIPE CORE

The core is made up on an iron cylinder called a core bar. This is wound with straw rope by rotating it mechanically and is then given successive coatings of clay-sand mud to bring it up to specified diameter. A loom board with a sharp edge scrapes off the surplus mud, smoothing the surface and forming a true cylinder of the wanted diameter. After a core has been partially formed it is placed in an oven for skin drying before receiving the last layer. The final surface is carefully finished and coated with blacking, and the core is next oven-dried overnight. When in a mold and after pouring, the heat of the molten iron penetrates the outer layers of the core and ignites the rope next to the core bar, thereby releasing the latter and permitting it to be withdrawn. In making small pipes, heavy spongy paper is substituted for straw rope.

To the foundryman and the trade, only straight, integral sections in standard lengths are called pipe. All bends, tees, crosses, and other irregular shapes are termed fittings. These, of necessity, require a different mode of manufacture, and separate shops are given over to that work. Then, too, tubular products that are neither tubes nor pipes constitute an important part of the company's business. These include cylinders of various sizes that are used as rolls in paper-making machines, laundry machines, etc. Some have interior strengthening ribs, either longitudinal or circumferential. Other special members of the pipe family are shells for heat exchangers that ultimately find service in the petroleum and chemical industries. Aside from pipelike products, the company turns out numerous miscellaneous castings of medium and large sizes. Typical examples are melting pans for such diverse processing industries as sugar mills and explosive factories. Cylinder blocks for steam-operated pile drivers are made in various sizes and up to 8,700 pounds in weight. In addition to plain iron, some nickel-iron and other alloys are cast, and some of the castings contain as much as 90 per cent steel. Warren Foundry is a licensee of the Meehanite process, by which it manufactures corrosion-resistant tubing and other products for the chemical industry. All these things are of interest; but at the present time we are chiefly concerned with the making of ordinary pipe.

RAMMING A FLASK

The flared bell section at the bottom of a flask is rammed by hand, after which the straight barrel section is mechanically rammed. The machine rammer has eleven tamping irons, arranged around a circle, and they are moved up and down by an arm extending from a power-driven wheel at pit-floor level. Meanwhile, sand is fed from overhead through a pipe in the middle of the rammer and the flask is rotated slowly by a turntable on which it stands. The tamping irons are held by magnetic grippers that exert the desired amount of tension but permit the irons to move progressively upward as the flask fills with sand. In ramming machines for small pipes the tension on the grippers is obtained with compressed air.

MAKING STRAW ROPE

Each year the foundry uses from 300 to 600 tons of straw. All of it is made into rope for wrapping core bars for pipe manufacture, as shown on the opposite page. Formerly, the twisting motion needed to make the rope was supplied by a workman, who turned a tool resembling a brace and bit and having on its forward end a hook to which the rope was attached. He walked backward slowly while the ropemaker fed straw to the lengthening strand. The work was done in a long shed; and the building where the rope is now fashioned is still called the rope shed. Today, the twisting is done by a power-driven reel. The rope is made in sizes from $\frac{1}{8}$ to 1 inch, and is wound into spools containing about 2,500 feet. Three spools is a day's work for a ropemaker. Only barley straw is used. A year's supply is bought from farmers in southern New Jersey as soon as the threshing season is over and is stored, in baled form, in a large building adjoining the rope shed. To render it pliable for rope making it is wet down a day before it is used.

Casting a length of pipe is a 2-day process: the mold and the core are made today, let us say, dried overnight, and poured full of metal tomorrow. After a brief period of cooling, the pipe is removed from the mold, cleaned, trimmed, coated with tar, tested, and marked for identification. Unless it calls for some special treatment, such as lining with cement, it may be shipped out tomorrow night.

Accompanying pictures show some of the activities in Shop 4 which, incidentally, is on the site where stood the first building erected by the company. This shop is devoted to the manufacture of pipe from 14 to 60 inches in diameter. Warren is one of two American foundries regularly producing pipe larger than 36 inches. Running approximately half the length of Shop 4 is a rectangular pit some 11 feet deep. In one end of the pit the molds are prepared: in the other end the casting is done. The cupola stands about midlength of the building and on one side and adjacent to the railroad tracks that deliver to it pig iron, scrap iron, coke, and limestone. The other half of the structure where there is no pit is given over to core making and storage. On one side are core-drying ovens and a clay mill. Overhead are three traveling cranes that are principally responsible for maintaining a rate of production that pioneer pipe founders

AIR COMPRESSOR AND PNEUMATIC GRINDER

Compressed air serves chiefly for operating pneumatic tools used in cleaning castings. A multivane grinder is shown at the right working on a cylinder block for a steam-operated pile driver. The compressor is an Ingersoll-Rand steam-driven unit that has been in service 33 years. It has a rated piston displacement of 1,319 cfm. at 150 rpm. It is located in the power house where steam-engine-driven generators of 700-kw. capacity are installed. The remainder of the power required is purchased. The greatest use of power is for operating traveling cranes.

probably never dreamt could be obtained.

Pipe has a laying length of 12 feet; but a section of the common bell-and-spigot type is made a few inches longer than that, the surplus at the spigot end extending into the bell end of the adjoining piece when they are assembled. The mold, in turn, is slightly longer than the pipe. The flask in which the former is prepared consists of two long iron members of semicircular section hinged so as to form a cylinder when closed and held together by clamps. The foundry casts all its own flasks. Pipes 14 inches or more in diameter are made one in a flask: lesser sizes are made from two to five in a flask. The latter is delivered by crane to the rammers and stood upright at one edge of the pit where its upper end will be conveniently accessible from the floor level above. All pipes 14 inches or more in diameter, which means everything handled in Shop 4, are cast with the bell at the bottom. Accordingly, the flask is placed on a ramming plate, on which rests the pattern for the bell. The pattern for the pipe barrel is then lowered into the flask. It is an iron cylinder having a diameter equal to the exterior diameter of the pipe to be made. At the flask bottom it fits into and is centered by a circular opening in the ramming plate.

The mold is then prepared by ramming sand into the annular space between the flask wall and the pattern. The bell at the bottom is rammed by hand, the lower few inches of the ramming tool being jointed so that it can reach into the flared pattern. The flask is rammed mechanically with a machine shown in an accompanying illustration. A few sledge-hammer blows serve to loosen the pattern from the enclosing sand. It is withdrawn a foot or two by the overhead crane, which then picks up the assembly and moves it to another position. As it is raised from the floor, the ramming plate and bell pattern are released by knocking off the clamps that hold them and they stay behind to be used with the next flask.

When the flask has been set down in its new position, the crane removes the cylindrical pattern. Next a workman impresses in reverse in the sand wall near the top of the flask identifying letters and numerals. These markings will appear in relief on the finished pipe and include the company initial, the year, and a number showing the order of casting. Sometimes other information is added. For example, all pipe made for the Board of Water Supply of the City of New York is marked W S N Y. The final operation consists of giving the sand wall a coat of blacking to prevent the sand from sticking to the metal after the pipe has been cast. The blacking is applied in liquid form and with amazing expertness by a workman who nonchalantly swings a bucket of the fluid around the interior of the cylinder with a single motion. Inspection reveals that every inch of the surface has been covered, and that scarcely any of the blacking has been left over to run out at the bottom. The base of the liquid is graphite, and into it also goes sufficient clay to give it the desired consistency and adhering qualities. The crane moves the finished mold into an oven where, still standing on end, it joins others. All ovens are fired with anthracite coal.

When molds for a prescribed number of inches of pipe have been made, the day's work of the molders is done. Meanwhile, at the other end of the shop, another group is preparing the cores that will be used with these molds tomorrow, and its shift likewise runs until the daily quota is completed. At the same time, the molds that were made yesterday are being poured in the section of the pit that is near the center of the long room, and as soon as that has been attended to the casters also will call it a day. All these men get on the job before six o'clock in the morning, and the time they put in depends somewhat upon the sizes of the molds and pipes in course of production. Ordinarily, however, they are on their way home around one o'clock in the afternoon. They work straight through the shift, hurriedly partaking now and then of food from their lunch pails without taking a minute from whatever they are doing. Overhead, the crane operators, sometimes shrouded in smoke, shuttle their mechanisms back and forth, handling flasks, cores, ladles of metal, and what not, striving to get everything that is needed at the right place the instant it is wanted. And most of the time they do it. An experienced shop crew, its members accustomed to working together, and every man knowing exactly the next move at every stage, puts on an inspiring show.

To the layman, the making of cores is perhaps the most enlightening phase of the operations. The core is placed concentrically within the flask mold, and the metal is poured into the annular space between the two. Naturally, the diameter of the core determines the pipe's wall thickness. Pipes of the same diameter but of different classes—that is, designed for different working pressures—have varying wall thicknesses, and the cores therefore have to be made to prescribed dimensions.

A core is built up around a core bar—a hollow iron cylinder cross braced with webbing and having a centrally disposed solid bar projecting a few inches at each end. There is a cross hole in each bar through which a pin is put to facilitate picking up the cylinder by a crane. Another purpose of the extensions is to serve as bearings for the core bar so that it can be revolved while the core is being built up on it. The revolving is done by means of a mechanical drive at one end. The first step in making the core is to wrap the core bar with straw rope, as shown in one of our illustrations. The reason for this seemingly curious practice is a simple and logical one, and will be explained a little later. The remainder of the core is a clay-sand mixture that is applied as a plastic mud and in several layers. The initial coating is a thin one of clay mud that adheres well to the straw rope. This is dumped on top of the revolving cylinder from buckets and distributed over the surface by hand. A so-called loom board, its edge faced with metal, is set a prescribed distance from the cylinder to scrape off surplus mud and to control the thickness of the layer. Next a thicker coating of a coarser and stiffer clay-sand mud is put on in the same manner. These two applications constitute what is termed the first layer, and the cylinder is then placed on a car rack with others and pushed into an oven to be skin dried. Later it is brought back to receive the final layer of mud made of clay and fine sand. It is applied with care so that its face will be perfectly smooth, for any irregularities will be transferred to the interior surface of the pipe. The diameter of the cylinder also must be closely controlled to give the desired wall thickness to the pipe. The end that goes down in the flask is tapered slightly so that it will make a tight fit with the bell mold to prevent leakage of metal along the joint. The finished core is given a coat of blacking by hand and is placed in an oven to be dried overnight.

The next morning the respective matching flasks and cores are brought together; the cores are carefully centered by gauging to insure pipe of uniform wall thickness; and casting gets underway. The iron is tapped from the cupola at about 2,800°F. and flows into a forehearth, where a flux is added to bring impurities to the surface. These are skimmed off, and the metal is run into a ladle and transferred by crane to the point of pouring. In both the flasks and core bars are numerous perforations to permit gases to escape from the metal. This action is stimulated by the use of sufficient coarse sand in the flask and core molds to give them porosity. After the metal has been in a flask for a short time, enough of its heat is transferred through the outer layers of the core to ignite the wrapping of straw rope around the bar. Owing to the absence of air it merely smolders; but this breaks it down sufficiently to release the core bar, enabling it to be withdrawn. The rope remains embedded in the clay and bursts into bright flames as soon as air reaches it.

After the pipe has cooled to a point below red heat, the flask assembly is lifted out of the pit, laid down, and opened. The pipe is placed on a rail runway and rolled out into the yard, where workmen with pneumatic chipping hammers remove any surplus metal and smooth up rough spots. Following this cleaning, the pipe is heated and dipped in coal tar to give it a protective coating both inside and out, except when it is to be lined with cement or other material. Then only the exterior is coated. Next comes the testing under hydrostatic pressure up to 400 pounds. Any leakage or sweating means rejection. Pipes passing inspection are weighed, and their weights are painted on them. When a cement lining is specified, it is applied by a spinning process.

Offhand, it would appear that pipes of varying sizes could be made ahead of time and stored until sold. This is true to only a small extent, as most large-scale pipe purchasers want their own markings cast on the pipes and also desire their own inspectors to be present during manufacture. The same thing applies generally to fittings; but as they are special castings that cannot be produced as fast as pipe, they are stocked in moderate quantities. The centrifugal-pipe plant of the company at Everett, Mass., is not equipped to make fittings: they are supplied by the Phillipsburg foundry, a sufficient stock being carried at Everett to meet ordinary demands.

There are about 460 employees in the Phillipsburg plant at present. As befits a concern of long standing, many of these workers have served for years. There are numerous father-and-son combinations among them, thus passing on the art of pipe casting today as it has been handed down in the past.

Since the formation of the present corporation, Leonard Peckitt has served as president. Still very active at 82, he can lay claim to being the oldest employee in point of both age and service, having started with an associate company 60 years ago. Other officers are J.L. Replogle, chairman of the board of directors; J.H. Morrison and S.B. Brown, the latter in charge of operations, vice-presidents; and L.R. Dohm, secretary and treasurer. John Tirrell is superintendent of the Phillipsburg plant. He started with the company 49 years ago as an office boy.

MACHINE SHOP

Flanged pipe, most pipe fittings, and special castings are machined before shipment. Equipment is available for handling and machining pipe sections up to 108 inches in diameter. Bell-and-spigot-type pipe needs no machining.

TUNNEL WORK AT WEST BRANCH RESERVOIR

Don H. Blanks*

TUNNELING OPERATIONS

Above—one of the few sections of the tunnel where the roof had to be supported with light steel sets. The ventilating tube, and the water, air, and power lines were carried on one side of the bore. At the right is shown one of the cherry pickers used for shifting cars. Note how the wheels, hung from a gate at each end, were swung aside and out of the way when the cherry picker was spotted or service.

THE LINE of the Delaware Aqueduct, after a southeasterly run of 44.6 miles from the intake at Rondout Reservoir, swings sharply more to the southward in the heart of Putnam County, N.Y. There the Frazier-Davis Construction Company has been at work since February, 1939, under Contract 321, which will entail outlays totaling about $11,924,450. The aqueduct will make the abrupt turn at the West Branch Reservoir, which is one of twelve basins distributed throughout the Croton watershed. All these reservoirs discharge into the Croton River, which was tapped in 1842 when New York City first went far afield for her general water supply.

Why, many have asked, has the Delaware Aqueduct been routed along a course that involves miles of additional tunneling instead of being led directly from the Rondout Reservoir, in the southern slopes of the Catskill Mountains, to Hill View Reservoir located near the northern boundary of the Metropolis? The answer is that the

*Vice-president Frazier-Davis Construction Company and general manager of the job under Contract 321.

SITE OF SHAFTS 10

An aerial view of the southern arm of the West Branch Reservoir, with the cofferdam under construction and not yet unwatered and excavated. At the lower right is a spoil dump of material from the shaft excavation.

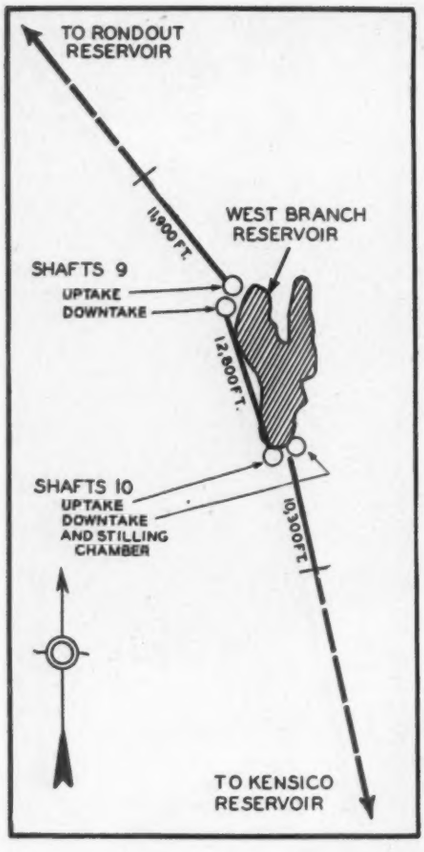
engineers of the Board of Water Supply have wisely elected to interconnect the Delaware Aqueduct at points with the headwaters of the two Croton Aqueducts —old and new, so-called—and with the Catskill Aqueduct built much later.

The earlier aqueducts were not interconnected and therefore have not been able to relieve one another in case of emergency. The work now in hand at the West Branch Reservoir is part of a corrective scheme that will make of all four aqueducts a well-balanced system of water supply that may be operated so that its component arteries will function separately or together, if need be. This arrangement will help to compensate for reduced rainfall in any of the contributive watersheds. By tapping the West Branch Reservoir, the Delaware Aqueduct will be able to deliver daily a volume of 100,000,000 gallons of water to the Hill View Reservoir. The flow line of the latter is 295 feet above sea level, and water from this main balancing basin can be distributed by gravity to all five of the boroughs instead of being pumped, as now, to certain sections at a large cost annually.

The West Branch Reservoir, which has a storage capacity of 10,000,000,000 gallons, is high in the mountainous region of Putnam County and its normal flow level is 503 feet above the sea, while the intakes of the Croton Aqueducts tap the southernmost and the lowest of all the reservoirs of the Croton watershed. It is admirably located to serve as a sedimentation basin for water reaching it from the Delaware Aqueduct, and it will also expose that water to the beneficial actions of the free winds and the sunshine. Before leaving the reservoir, the water may be subjected to chlorination should objectionable microörganisms be found present. Furthermore, by linking the Delaware Aqueduct with the Croton system, the Metropolis will be the gainer, as well as those communities northward of New York that long have been largely if not wholly dependent upon the Croton watershed for their supply. The detour of the Delaware Aqueduct to the West Branch Reservoir is a safeguard that will prove its value in the decades to come.

Under Contract 321, the Frazier-Davis Construction Company is called upon to drive a total of 35,000 linear feet of tunnel of large diameter deep in the rock and to build big and decidedly complicated control stations at two points on the shores of the West Branch Reservoir—one to admit water from the slopes of the Catskills, and the other to lead back into the main artery of the Delaware Aqueduct an admixture of Catskill and Croton waters. A by-pass tunnel will link these two stations, which will be 12,800 feet apart, and will permit water in the Delaware Aqueduct to flow without interruption southward past the West Branch Reservoir. This provision for alternate service is an important one and will, incidentally, increase the potential flexibility of the system and fit it to meet a variety of conditions.

When the Frazier-Davis contract was



LOCATION MAP

This sketch shows the course and length of the tunnels driven under the contract described in the accompanying article and the locations of the shafts from which the work was carried on.

awarded on January 4, 1939, twin shafts already had been sunk under a previous contract, and these were to serve as bases from which to advance the tunnel sections. The shafts had stood idle long enough to be flooded up to the level of the groundwater plane, and had to be unwatered by pumping before work could proceed. Tunnel driving was started from three headings in the following order: north and south headings from Shafts 9 about June 24, 1939, and the heading south from Shafts 10 on August 23, 1939.

The twin shafts designated as Shafts 9, uptake and downtake, are located on the south shore of the western arm of the West Branch Reservoir, while Shafts 10 are on the opposite shore and at the southernmost end of the basin. Downtake Shaft 9 and Uptake Shaft 10 will be linked by the 12,800-foot by-pass tunnel, which will have a finished diameter of 15 feet. At this writing, the latter has been advanced more than 9,000 feet from Downtake Shaft 9, while another section, with an inside diameter of 13½ feet and 11,900 feet long, is being pushed northwestward from Uptake Shaft 9. The expectations are that both will be finished, so far as excavating is concerned, by Christmas, 1940. South and easterly from Shafts 10, a second 15-foot section, which constitutes the northernmost end of the aqueduct between the West Branch and Kensico reservoirs, has been driven the prescribed distance of 10,300 feet and the work of lining it with concrete is underway.

The construction of the gate chamber and other headworks at the influent station at Shafts 9 will be begun when the tunnels advancing from those shafts are completed; but at Shafts 10, underground operations are being pushed on the enlargement of the upper part of the downtake shaft that will form an immense control or stilling chamber. This will rob the water discharged into it of its great destructive energy as it drops 148 feet—the head or difference between the normal flow levels of West Branch Reservoir and of Kensico Reservoir. It is said that this flow may range from slightly less than 200,000,000 gallons to more than 1,000,000,000 gallons daily.

The work on this feature of the effluent station includes not only the enlargement of Downtake Shaft 10 from a finished diameter of 15 feet to as much as 45 feet throughout a vertical length of about 110 feet but also the sinking of two flanking 22-foot shafts which will carry downflow pipes, each 4 feet in diameter. There will be five pipes in each side shaft and they will be fitted with bronze nozzles that will be directed toward the center of the stilling chamber where the jets from opposite sides will meet, thus reducing their velocity and power to damage. The sinking and enlarging operations are being done with X-59 sinkers; and the placing of the concrete lining keeps pace with them to give the remaining rock proper support.

The underground work in connection with the effluent station is going forward in a cofferdam which has a length of approximately 870 feet. It is made up of sixteen circular steel-sheet-piling cells filled with excavated material and is linked with the shore by earth embankments, one at each end, stiffened with a line of piling. After unwatering and the removal of the overburden, the remaining rock was excavated with the aid of two FM-2 wagon drills and seven X-59 sinkers. The wall immediately back of Downtake Shaft 10 and the two down-pipe shafts was carried to a depth of 100 feet; and the deepest part of the cofferdam is about 60 feet above the floor of the unwatered area. The top of Downtake Shaft 10 has been removed to the level of the bottom of the excavation and is now sealed with a concrete cap to protect it against flooding in case of any failure of the cofferdam.

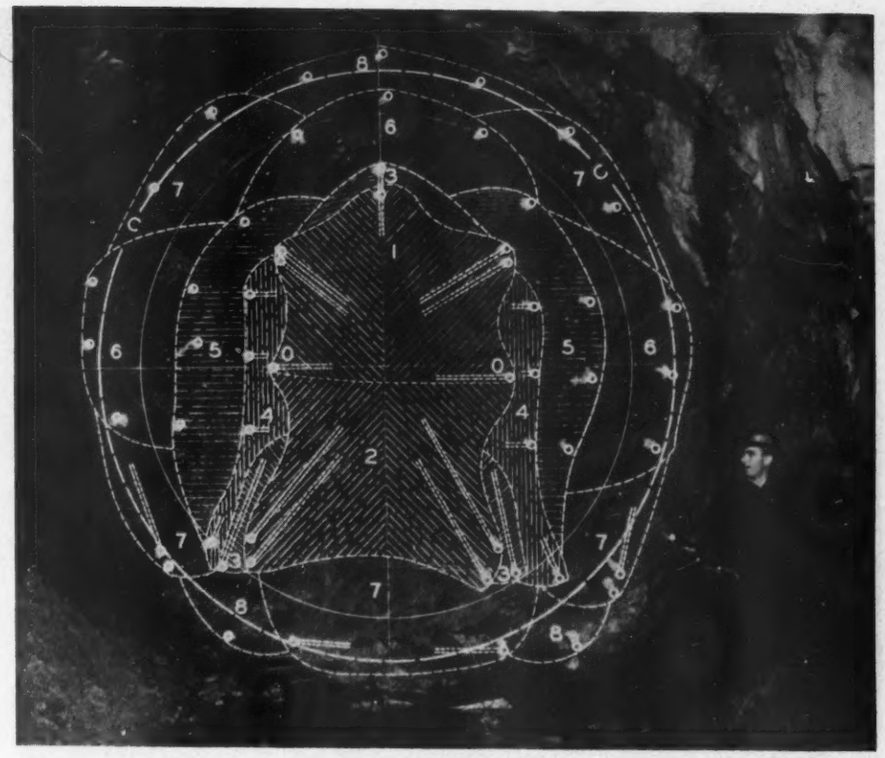
All major contracts for the Delaware Aqueduct contain this highly suggestive paragraph: "It is the purpose of the Board to build the works under its charge in the shortest time consistent with good construction. To this end, the Contractor will be required to use improved methods and appliances for doing the various parts of

DRILL CARRIAGE

In each of the tunnel sections, one of these units made it possible to drill the entire heading with one set-up. This picture shows the carriage and one of the drilling crews in the tunnel that was driven northward from Uptake Shaft 9. Nine Ingersoll-Rand drifter drills are mounted on the structure.

the work. Complete and well-designed construction plants and effective organization will be insisted upon." How full has been the response of the Frazier-Davis Construction Company to the foregoing requirements is best indicated by the progress made since tunnel driving got underway at the three headings.

Shafts 9 are 50 feet apart on centers, and as originally sunk were not open to each other at the bottom. But to aid in tunneling and in the handling of materials and muck, the present contractor dug a common chamber between the two and equipped the downtake shaft with a high headframe and two counterbalancing muck skips and man cages. Over the uptake shaft was erected a much lower headframe provided with a hoist to serve only for lifting and lowering essential materials and equipment. The double-skip headframe brings to the ground surface all muck from the by-pass-tunnel heading as well as from the heading proceeding north and westward. Uptake Shaft 9 has a finished diameter of 14 feet, while that of the downtake shaft is 15 feet. The tall headframe is served by a Lidgerwood hoist that is driven by a 250-hp. General Electric motor—the hoisting speed ranging from 350 to 400 linear feet a minute. This hoist has a standby Type 30 compressor of 7½-hp. to operate the brakes in case of any shutdown of the main air line. Both shafts are approximately 320 feet deep.



TYPICAL DRILL ROUND

This diagram was plotted on a photograph of a heading. The cut holes at each side of the center line were fired instantaneously, and the other holes were fired in delays running from 1 to 8.

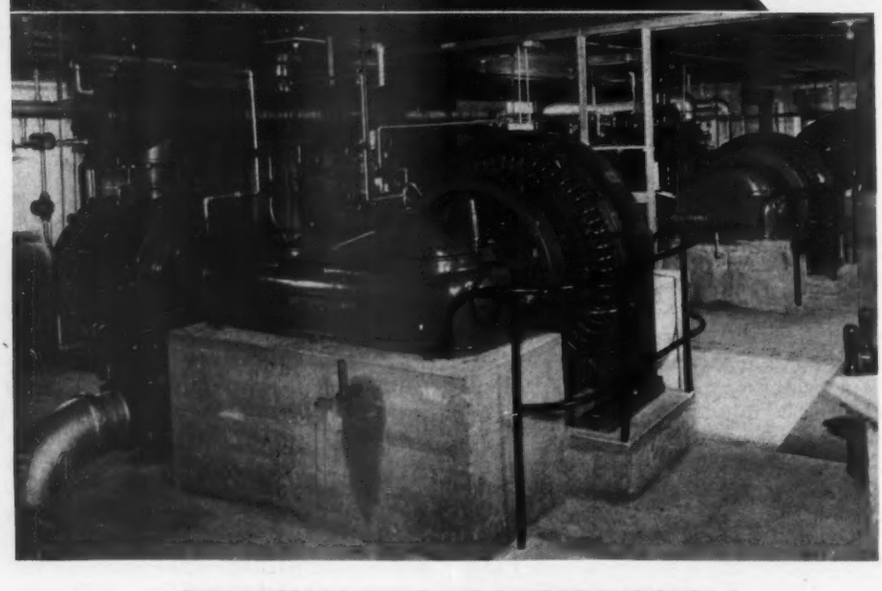
At the bottom of Downtake Shaft 9 is a loading pit below the tunnel floor for the two skips each of which has a capacity of 6 cubic yards. The muck cars are of the same capacity. They are of the Koppel side-dump type and are tipped by hand when discharging. Muck trains are made up of seven or eight cars; and there are 60 cars in service in the two tunnel sections being driven from Shafts 9. The hauling is done by eight storage-battery locomotives built variously by Goodman, General Electric, and Whitcomb. The batteries are charged at an underground station in the chamber at the bottom of the two shafts. In the same chamber are housed the drill doctors, and there, too, is located a storeroom for spare parts for tunnel-driving equipment.

At the ground surface adjacent to Shafts 9 are a machine shop and a blacksmith shop, both well equipped. The drill rods are of 1¼-inch, round Leyner steel. The starters are 3 feet long, and the increase with each successive change is 2 feet—the final steels being 13 feet in length. All drill rods carry detachable bits: the starters are 2¼ inches and the finishing bits 1¾ inches in diameter—the reduction with each change being ⅛ inch. In the blacksmith shop there are two No. 27 Ingersoll-Rand oil furnaces, two I-R sharpeners—a No. 54 and a No. 50, one No. 500 cutoff machine, two 4-P pedestal grinders, and a Jones & Lamson turret lathe for threading drill rods. Compressed air for underground work on this phase of the contract is supplied by a surface plant in which the newest of the units are an XRE 175-hp. machine and an XCB of 125-hp. Ventilating air for the two tunnel sections is furnished by two 125-hp. blowers, each of 12,000-cfm. capacity. The air is led down each shaft and to its heading by way of 28-inch vent pipe made up of 24-foot lengths.

All muck from Shafts 9 is sterilized for disposal after being loaded in trucks that take it from the 150-cubic-yard hopper on the headframe above the downtake shaft. This is required by the Board of Water Supply because the excavated material is placed in two spoil areas—one near the shafts and convenient to a crushing plant, and the other on the opposite shore of the west arm of the reservoir where the muck has filled out and risen above a submerged section set aside for storage purposes. Sterilizing prevents pollution of the water in the reservoir. The disinfecting station is adjacent to the downtake shaft, and each loaded truck is sprayed at the rate of 4 gallons per cubic yard of muck. The solution used contains 1 pound of chlorine for each 100 pounds of water; and the chlorine is obtained from a bleaching powder that has a 35 per cent available chlorine content The disinfectant is circulated from a 2,000-gallon wood-stave tank by an RV 1½-hp. pump having a capacity of 100 gpm. There are two of these units in the mixing plant—one constituting a reserve.

In driving the 13½-foot section north from Shafts 9, the excavated cross section has averaged 16½ feet. The average advance in a 5-day week, working three 8-hour shifts a day, has been 160 feet, and the maximum 180 feet. In general, the by-pass tunnel has an excavated cross section of 18 feet, and there the weekly advance has averaged 190 feet, with a maximum of 226 feet. The rock in the north heading has been found to be about 25 per cent harder than that in the south one and consists largely of gneisses, with some schists and interbedded limestones and considerable hornblende at places. The average pull from a 9-foot drilling round has been 8¼ feet, and because of rock variations, the drilling time has ranged from two to six hours, with an average of three hours. At the south heading, when drilling 11-foot rounds, the pull has averaged 10 feet, and the drilling time has been from 1½ to 3½ hours, with an average of 2½ hours. Mucking time at the north heading, including moving in and out, has been about two hours, whereas at the south and larger heading it has been around three hours.

The drill carriages at the two headings are rectangular in form and fabricated of structural-steel parts. Each mounts seven drills at its forward end—three on top and two on each front side column. The machines are Ingersoll-Rand S-70 drifters with power feed. At the rear, on the top platform, are two DA-35's, and these are used to drill holes for engineers' plugs, etc. At the north heading, the average round consists of 42 holes, and each of the seven



COMPRESSORS AND STEEL-SHARPENING SHOP

The lower picture shows three Ingersoll-Rand synchronous-motor-driven compressors that furnish air at Shafts 10. The other views are of the blacksmith shop at Shafts 9. It is equipped with two oil-fired furnaces, two drill-steel sharpeners, and three grinders. One of the latter, a No. 500 cutoff wheel, is at the upper left.

drifters drills six holes. The cut holes are 11 feet deep, and the side and trim holes are 9 feet deep. From 40 to 60 minutes are required to load and shoot a round and from 400 to 500 pounds of explosive is used per round. The four cut holes are loaded with 60 per cent powder, and the others with 40 per cent. Shots are fired from a station 2,000 feet back from each face; and the firing circuit is hung along the free side of the tunnel section, all water and air lines and power cables being confined to one side as a precaution against stray currents that might cause trouble. A safety blasting system is rigidly adhered to.

A Conway 75 mucker does the loading at each heading; and at the north heading the work takes about two hours. The mucker can fill a 6-cubic-yard car in 1½ minutes and moves, together with the dump cars and the drill carriage, on the 3-foot-gauge main track. In making up a train during loading, the empties are handled successively by an independent cherry picker that is spotted about 175 feet back from the heading. On top of the cherry picker is an electric motor for lifting the cars, and at each end, suspended from a gate built of welded piping, are two car wheels set at 3-foot gauge. These gates are swung to one side, out of the way, when the structure is wedged up and ready to handle cars; and they are closed so that the wheels can engage the track when the wedges are removed and the cherry picker is lowered in readiness for shifting.

The drill carriages are somewhat smaller than combined drill carriages and cherry pickers and can, it is said, get closer to a face, making it easier to reach the corners when drilling. Each mounts, on its upper platform, an electrically driven blower having a capacity of 12,000 cfm. This improves ventilation at the heading and prevents fogging from the exhaust of the drills. The discharge end of the vent pipe is about 100 feet back from the face. Immediately after a shot, the action of the blower is reversed so as to suck out smoke and gases for a period of twenty minutes.

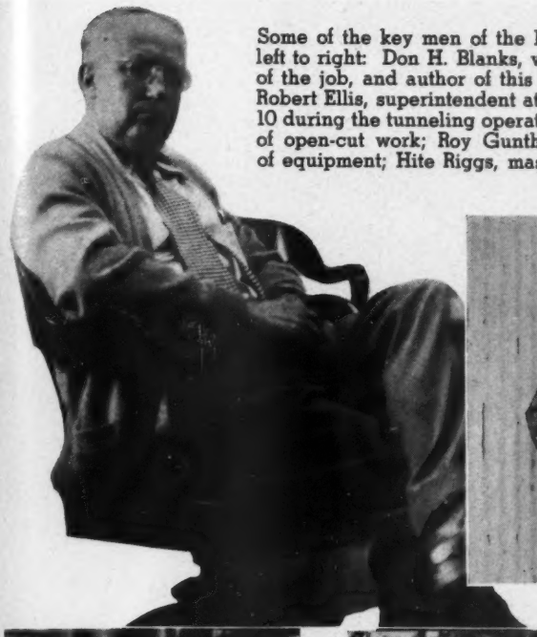
While the rock generally has stood up well during tunneling from Shafts 9, still it has been inclined to pop or spall because of compressive stresses when exposed to the air. Guniting has been resorted to to check this tendency—the arch section being coated in this way from a level about 2 feet above the springing line on each side. But little steel has been required for roof support, and only at a few places. There is an I-R No. 25 sump pump at each heading, and both tunnel sections are drained by three pumps—two of them Ingersoll-Rand units—that have a combined capacity of 2,000 gpm. When the sections have been driven and lined, the connecting chamber at the bottom of the twin shafts will be sealed by a great reinforced plug of concrete so that the water from the Catskills will either rise through the uptake shaft to reach the West Branch Reservoir by the influent channel or descend through the downtake shaft to sidestep the reservoir by flowing through the by-pass tunnel.

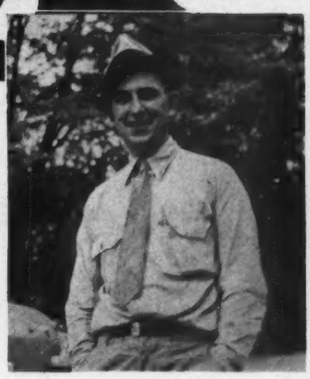
The rock excavated in advancing north and south from Shafts 9 is acceptable as an aggregate for concrete for tunnel lining; and adjacent to the shaft is a crushing plant with a capacity of 1,000 cubic yards per 8-hour day. A primary and a secondary crusher are in service there, and these reduce the rock to maximum sizes of 4½ and 1½ inches, respectively. The crushed stone is stored at two points within convenient reach of either Shafts 9 or Shafts 10.

At Shafts 10, the 10,300 linear feet of

PERSONNEL

Some of the key men of the Frazier-Davis Construction Company. Top row, left to right: Don H. Blanks, vice-president of the company, general manager of the job, and author of this article; Fred Youmans, general superintendent; Robert Ellis, superintendent at Shafts 9; Walter Baer, superintendent at Shafts 10 during the tunneling operations. Bottom row: Tom Hudson, superintendent of open-cut work; Roy Gunther, field engineer; John Wills, superintendent of equipment; Hite Riggs, master mechanic.





tunnel extending southward from the West Branch Reservoir was not driven, as might be expected, from the downtake shaft but, instead, from the uptake shaft, with which the by-pass tunnel is to connect. This arrangement was decided upon to leave the downtake shaft free in order that the protracted and exacting work of excavating the stilling chamber could be carried on without interference. Accordingly, all muck and materials in connection with the driving of that tunnel section has passed through the uptake shaft, which was provided with a headframe equipped with two counter-balancing, 6-cubic-yard skips each surmounted by a man cage. But before the shaft could be used for that purpose, it was necessary to deepen it about 100 feet to reach the projected line. It was sunk to an ultimate depth of approximately 437 feet; and at that point the work of tunneling was started. Shafts 10 are 127 feet apart on centers; and the contractor had to excavate that distance to intersect the tunnel line at the bottom of the downtake shaft. The section was completed on August 14, 1940.

The hoist at Uptake Shaft 10 is similar in make and power to that of the main headframe at Shafts 9; and the air required for pneumatic braking is furnished by two 7½-hp. Type 30 compressors—one a standby unit. The muck hopper has a capacity of 75 cubic yards; and the gate of the discharge chute is opened and closed by three air cylinders. For tunnel driving the compressor plant was provided with three XRE machines of 175 hp. each—two 18&11x14-inch units and one 18&11x12-inch with 5-step clearance control—and the pumps used were of the same make and total capacity as those at the other shafts. The gates of the cement bins are operated by means of compressed air supplied by a Type 30 of 7½ hp. Ventilating air has been provided by a blower with a capacity of 12,000 cfm., and the vent pipe is 28 inches in diameter. When the section is completed, the drift between the bottoms of Shafts 10 will be closed with a plug or bulkhead of reinforced concrete.

In driving the tunnel from Uptake Shaft 10, the drill carriage, with a crew of from twelve to fourteen men, the cherry picker, the mucking machine, and the drills used were the same as those already described. Different kinds of gneiss, granite, and diorite, with occasional limestone, were penetrated; and as the rock varied to a marked degree in hardness and toughness, the rate of advance changed accordingly. In favorable rock, the drilling of a round required about 3½ hours; but the time was approximately double that in some granite and hard gneiss. Drill rounds were from 11 to 13 feet in depth, and the pull ranged from 7½ to 10½ feet. Shooting practice, arrangement of the firing circuit, and procedure in ventilating the heading after a shot did not differ from similar operations at the north and south headings from Shafts 9.

Work under Contract 321 is going forward under the immediate direction of the author of this article, with Fred Youmans as general superintendent. Robert Ellis is superintendent at Shafts 9, and Walter Baer was superintendent at Shafts 10 during the driving of the tunnel southward from that point. Tom Hudson was superintendent of open-cut excavation and is now concentrating on the two down-pipe shafts and the underground work in connection with the enlargement of Downtake Shaft 10 for the flow-control chamber of the effluent system. John Wills is superintendent of equipment; Roy Gunther is field engineer; Hite Riggs is master mechanic; and Ted McCoy is night superintendent.

SAFETY IN MINE DRILLING

T. G. Murdock*

THE modern rock drill plays an important part in mining and construction work. It also presents a safety problem, requiring, for some operations, considerable thought on the part of the management, work by the supervisory organization, and complete cooperation from the workmen, with strict obedience to safety rules and the dictates of common sense.

This paper contains little that is new; but it does consider various pertinent safety factors based on the study of hundreds of drilling accidents and observations in mines of four countries. As a general premise it can be stated that fundamental safety measures, when directed against drilling accidents, will prevent such accidents. These measures recognize the basic principle that accidents are avoided by working in the safe way, which is also the correct and efficient way. Every organized safety campaign should include safety education, with special emphasis on proper drilling procedure. This will be conducive both to better performance and fewer accidents.

Most drilling accidents are undoubtedly caused by some careless, negligent, or improper act of the driller or helper. The mine operator can do his share towards preventing them by carefully selecting the drilling equipment and accessories that are best suited for the particular conditions. The percentage of the total mine accidents attributable to drilling varies with individual properties and with local conditions. The experience of the drilling personnel is certainly an important factor. However, drilling accidents do not necessarily happen only to new workmen, for experienced ones are frequently injured in a careless moment. I do not have available recent statistics for the industry as a whole, but some years ago, during a 7-year period in a western mining state, drilling accidents resulting in permanent or temporary disability totaled 1,113, or almost 6 per cent of all the mine accidents, not counting 48 fatal and serious ones caused by drilling into missed holes. I know of one mine where drilling accidents, representing 12 per cent of all accidents during three successive years, were reduced proportionally, as were total accidents, by organized, aggressive safety work.

Falls of ground during drilling are too frequently a source of accidents. These are generally serious, and to prevent them it is necessary to consider the fundamental fact that ground changes. Both the miner and the boss must be continually on guard and see to it that a bad back is carefully barred down and the working place properly timbered. This must be done before drilling starts; and experience at practically all metal mines proves that the miner must inspect, test, and bar down

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TEAMWORK

Regardless of the type of drill used, there must be perfect co-ordination between the driller and the helper in the various operations that enter into drilling. Each must consider the safety of the other and permit no clumsy movement on his part to cause injury to the other.

the back several times during a shift, even "popping" dangerous slabs which cannot be barred down before working under them. The vibration set up by drilling undoubtedly tends to open up minute cracks and crevices in apparently solid rock, thus increasing the need of frequently inspecting the back during the drilling cycle.

Drilling operations may also influence the future safety of a working place. For example, careless hole location may cause an unsafe condition and even an accident. In many kinds of stoping, if the hole enters wall rock and is blasted, the wall rock supporting adjacent ground which does not stand so well will be broken and a safe working place may become a source of trouble, expense, and even danger. This is true in drifting in certain formations. The location and angle at which the "uppers" are drilled may be such that the explosive will break the rock and form a series of slabs between rounds that will fall later. This condition may come about through the improper placing of slabbing holes at the side of a drift or other development working. Most mines have standard rounds for various purposes. These should be carefully planned and conscientiously taught to the drillers.

After taking precautions to assure the safety of the place as a whole, the drilling site should be made even safer by barring down the smaller pieces of rock. In many kinds of ground this small scale falls easily and may inflict painful cuts and bruises, resulting in serious infection if neglected.(1) The bar, it should be stressed, is the proper tool for bringing down both the large slabs and the smaller scale. When barring down, the miner should stand in a safe place, and this is not possible when using a pick, a piece of drill steel, or whatever may be handy. The pick is useful for removing loose rock from the side or face of a drift, but should never be employed for working overhead.

Another essential precaution before starting drilling is to carefully examine the face for misfire holes. In most mines there is a mucking cycle between blasting and drilling—at least some mucking is generally necessary to permit drilling. The operations of making the place safe from falls of ground and of inspecting for failed holes should precede mucking, but it is not being overcautious to repeat them before and during drilling.

Perhaps most mines have had at least one accident due to drilling into a missed hole. Naturally, measures to prevent such an occurrence should start with blasting, when an effort should be made to avoid creating such holes. Shots should be carefully counted when fuse blasting is resorted to. If another shift is coming on, it is imperative that the crew be notified of any failed hole. Most state mining laws and local safety regulations include precautions to be taken in case of a missed hole, and these should be followed faithfully. Shooting a misfire hole by lighting the old fuse may be dangerous, for it might be only 6 inches long. All supervisory forces should follow the practice of carefully examining for missed holes any face where the work of advance stops. Later, when resumed, it may be very difficult to find them, or a connection may be driven from another direction. The danger of drilling in an old hole, or part of one, is self-evident, but accidents still happen because of failure to observe a cardinal rule.

The driller should also take measures to make the working place safe before even starting to set up. Good housekeeping is essential during drilling; and before drilling is begun, any objects presenting a stumbling or tripping hazard should be set to one side or otherwise disposed of. Pipe lines should be fastened firmly, and raise miners should see to it that stulls and platforms are secure and free from loose rock that might fall off. If drill steel is carelessly thrown on the floor it is a potential stumbling or slipping hazard, and when stood up it should be placed so that it will not fall on the driller. Any loose timber should be well blocked; and if the working needs to be timbered or retimbered this should be done before drilling starts. (1) In many mines it is the practice to protect the men during the drilling cycle by means of temporary stulls with headboards. This should be done more generally; but, naturally, any ground that requires barring down should not be timbered. Barring down will not only eliminate a source of possible injury but also facilitate collaring a hole.

In delivering drilling equipment and steel to the face, whether by the driller or nipper, the first consideration should be

(1) Ferguson, Claude, "Prevention of Accidents from Falls of Rock in Metal Mines," *Mining and Metallurgy*, June, 1938.

TRANSPORTING DRILLS

A driller can carry a light machine (right) along a drift on his shoulder without hazard provided he is not loaded down with too many other objects at the same time. Care must be taken when he puts the drill down to guard against injuries to his fingers and feet. Drifters and stopers can be transported safely on the shoulders of two men, but both should be on the same side of the load, should keep in step when walking, and should pick the drill up and put it down carefully and with mutual understanding.

COLLARING A HOLE

It is common practice, when starting a hole with a Jackhamer, to hold the steel between the feet. This presents a serious hazard. If the steel breaks, there is danger of the drill falling and causing a foot injury. It is also possible that the driller's hand will strike the projecting piece of steel. Once the hole is collared, it is easy for the driller to stand clear of danger, but he should remain alert so as to prevent possible hand injuries.

safety. For heavier machines that have to be transported on cars, it is better to use low trucks such as serve to haul timber, and perhaps with a steel platform. If the higher ore cars are employed for this purpose there is the danger of derailment on curves by reason of unequal distribution of weight or shifting of the load, to say nothing of pinched fingers during loading. Furthermore, in tramming a car so laden, the men must be on the lookout for protruding obstacles that might come in contact with the machinery and either damage it or injure the men. Taking the equipment up a raise also requires considerable skill and care. This matter of the safe handling and moving of heavy drilling machinery and supplies to the face of a raise or tributary working should always be considered in laying out development work and schedules.

The delivery of drill steel presents several serious accident hazards of which perhaps the worst is that of carrying it on the shoulder in places where there are unguarded trolleys. This danger must be continually kept before the men and even weighed as a point in favor of storage-battery locomotives when haulage equipment is first installed. Trolley guarding, at least in the most traveled haulageways, is a vital safety measure. Power and even light lines hung from the back of an opening where men have to take drill steel present a menace, especially in a wet mine, and efforts should be made to install and to maintain these lines with maximum safety in view. Carrying steel on shoulders is prohibited in most mines.

When steel arrives at the shaft station it is important that it be neatly stacked in appropriate storage or transferred to a tool shack. It is very dangerous to dump steel off a cage and leave it there, as a piece may later fall down the shaft. The same thing is true of the top of a raise or winze where steel lying about carelessly may also cause someone to trip and fall down the opening. Carrying steel up a raise is perhaps more dangerous than carrying the drill. It takes a skilled man to climb a ladder with several lengths in his arms; and when two men pass it up piece by piece the upper man is liable to fumble and let one slip. Tying a complete set together gives better results. Throwing steel down a manway is one of the worst possible habits and should never be permitted, for the ladder rungs might easily be damaged, or the steel hit someone who happened to be near the foot of the raise. Besides, steel striking steel causes "nickage" with the likelihood of breakage later.

When a workman is engaged in bringing explosives to the face, he should not carry anything else on the same trip. Mashing a cap between two pieces of steel while going up a raise, or spilling oil on a fuse, may prove disastrous. Modern practice, and in some cases legislation, require the use of proper containers for explosives, thus assuring transportation to the face with reasonable safety. But, even so, the man should not have to concern himself with anything other than the explosives.

By reason of the increasing application of detachable bits and the consequent reduction in the use of drill rods, the risk attending the handling of the latter is naturally greatly lessened. This advantage, a very important one from the safety standpoint and a strong argument in favor of detachable bits, can hardly be expressed in dollars and cents; but it should be remembered when the costs of detachable bits and regular drill steel are compared. Under certain local conditions it may compensate for a considerable difference in actual drilling and nipping costs which, on a footage basis, would seem to indicate that the use of regular drill steel is preferable.

The operation of setting-up frequently results in an accident, especially in the case of heavy drifters. With hand-held machines the work is simple. About all that is necessary is to connect the air hose so that it will not come loose and whip around like a snake, striking the driller or blowing dirt into his eyes. Naturally, it is impossible to do much drilling without catching several threads of the hose spud; but if the driller just starts to do this, forgets, and turns on the air at the other end of the hose with the throttle valve open, something will happen. Drillers also have been known to pinch their fingers while chucking in the steel or closing the steel holder.

In setting up a stoper, an additional precaution is necessary, at least in drilling inclined holes. The footboard should be placed perpendicular to the machine so that the latter will not slip and fall on the driller's foot or leg. In setting up a drifter, accidents are often caused by the careless use of a spanner wrench, or using a worn one. A wrench that slips, almost invariably leads to barked knuckles, and an arm may strike a sharp rock in the side of the drift and receive a nasty cut. The driller also may find himself in need of dental work. The wrenches, and the bolts as well, should be inspected, tried frequently, and changed at the first indication of dangerous wear. Further, the machine man should keep his face some distance from the wrench, and he should pull not push the tool. Blocking the jack bar is another operation that may mean a trip to the dispensary, at least. A light sledge, with the

DRILL-STEEL CAR

A car with compartments for different lengths of steel is a useful piece of equipment, both for handling the steel in the shaft and for transporting it by rail to different distribution points in the mine. In a mine that uses relatively small amounts of steel, and where men are ordinarily carried on the same trip with the steel, it is a safe practice to provide a long wooden box for the cage and to fasten the steel securely in it.

handle a tight fit and free of splinters, is the proper tool for driving a wedge: under no conditions should a starter be employed for this purpose. When driving a wedge there is a possibility that the hammer may strike the back and that a small fragment or rock may glance off and into an eye. It is therefore advisable to wear goggles.

The blocking should be handy and ready for use before the jack bar is raised. The latter should be securely placed and retightened after starting to drill so that there is no danger of its coming loose while drilling is going on. The safety collar that fits on the bar below the crossarm should always be properly and firmly fastened so that it will really function as it should. These collars have a habit of disappearing, and the mine supervisory force should insist that they be considered and used as an integral part of the drill and not taken off and forgotten at the first opportunity.

Both driller and helper should take part in the operation of moving the crossarm on the bar, being careful not to place their hands on the free end of the crossarm. I know of one case where the machine was set up off center when turning from a branch working, and the helper broke a finger when it was caught between the end of the arm and the side of the drift. Many accidents that occur while setting-up are the result of needless haste to finish the operation and to start drilling again. Generally there is ample time to set up carefully and to get the round in and blasted before the end of the shift. In tunneling and even in drifting, where speed is an important consideration, the use of a portable drill carriage will undoubtedly expedite matters without unduly increasing the likelihood of injury.

Of all the detailed operations of the drilling cycle, the work of collaring is perhaps the most fruitful of accidents. Eye injuries are prevalent at this time unless goggles are worn, and both driller and helper should be so protected preferably the entire drilling period, but by all means when collaring and blowing. There is a satisfactory goggle of either wire screen or tough unsplinterable glass, even corrected for individual vision, for every mine, and its use during drilling should be required and enforced. When this is not done, the inevitable consequence is "something in the eye." The workman concerned usually rubs it, it may feel better, and he finishes the shift; but by the time he gets to the dispensary he has an infected eye. Prompt treatment of even the most trivial hurt of any kind by a qualified person is demanded at most mines, and in the case of the eye is essential if the injury is not to become serious. The wearing of goggles for all work, where there is no danger of something more serious happening because of limited vision, is a basic principle of accident prevention.

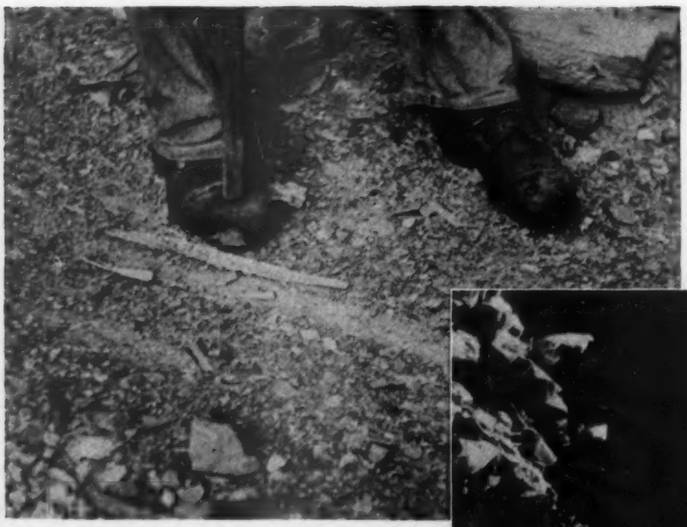
The holding of the drill steel by the helper during collaring also introduces a possible hazard—he may get his fingers caught between the steel and the rock. Some helpers on drifters follow the recommended practice of holding the steel with a spanner wrench when collaring a hole; but others try to support it with another piece of steel resting on a rock or on a third piece projecting from another hole. If a steel breaks with a hand-held machine the driller usually loses his balance and falls, and the drifter may shoot forward and catch the helper. A stoper also may fall, and in doing so hit the driller's foot or legs. When collaring a hole with a stoper a certain amount of rock around the collar frequently spalls and falls despite the fact that the face was carefully prepared before drilling was started. The driller must be mindful of this, and by wearing gloves will usually avoid injury from such pieces of rock. In fact, the use of gloves will prevent many minor scratches, cuts, and bruises throughout the entire drilling operation. The precautions taken during collaring should be continued until the hole is completed. In some kinds of drilling it is possible to reduce the hazard incidental to broken drill steel, for once the hole is collared the driller and helper can stand clear of it. However, they should not lessen their vigilance, for there is still danger of a hand injury where vertical holes are drilled by means of a machine held by hand.

SUPERVISION

The supervisor—whether superintendent, foreman, or shift boss—must recognize his responsibility as regards accident prevention among the members of his group. In regularly inspecting working places, he should at all times emphasize safety and promote safe practices by telling the men, showing them, checking them, and testing them. By doing these things he can become a powerful influence in accident prevention

Regarding a broken steel when drilling uppers with a stoper, A. S. Bayne, Inspector of Mines, Port Arthur, Ontario, has said: "Miners experienced in handling stopers know that the only time to hold the machine by the rotating handle is while lifting the drill to collar a hole . . . . When drilling, after the hole is collared, the machine is steadied by standing as far away from it as possible and holding the air hose in the hands. Then if a steel breaks, a tug on the hose pulls the drill down and the feed piston away from the operator, or if the hose becomes uncoupled it cannot fly around and hit the operator, as he is already holding it in his hands."

Changing drill steel presents no special hazard provided it is done with care to prevent dropping the steel on the feet or striking a fellow workman. Incidentally, steel changes should be made as specified, and not by jumping from a starter to the longest piece. The chances of a broken steel and consequent injury from this or some other cause are increased, especially in drilling with a hand-held machine, when 5 or 6 feet of steel are sticking out of a hole. The mine operator can do much to prevent steel breakage by selecting, after adequate experimenting, the brand and section of steel best suited to his conditions. How-



PREVENTING FOOT INJURIES

Where drilling is done from the muck pile, any rocks that might roll down on the driller should be removed and a firm footing provided. Time taken to level off a bench on which to stand is well spent. The footing pictured below is insecure. The driller is in danger of falling, or he may sustain a sprained ankle by stepping on a projecting rock. The wearing of hard-toed shoes (left) is rapidly becoming mandatory in progressive mines. It is especially advisable to use them in all operations involving the handling of rock drills or steel.

ever, the driller can help to some extent, for some breakage results from straightening bent steel which, in turn, is often due to releasing stuck steel by blasting. Surface "nickage" is recognized as a frequent cause of breakage, a factor that can be aggravated by careless handling of the steel by the driller. This is another argument in favor of detachable bits.

Every effort should be made to prevent drill steel from sticking. When withdrawing one by pulling on a hand-held drill, the bit may come out of the hole suddenly and the machine may strike the driller, or he may fall backward or against the side of the working place. Various tools have been devised to withdraw stuck steel, or steel with the shank broken off. These are of different types, and include a long-handled wrench, forged out of a length of steel, which fits over the top of the broken piece of sections other than round. The use of an ordinary pipe wrench for this purpose frequently results in an accident because the jaws are sometimes worn and the wrench slips. A piece of drill steel should never, under any condition, be left sticking out of the back, floor, or side of a working place because it may be the means of a serious injury should someone run into it.

Mention has already been made of goggles and gloves as important items of safety equipment. Protective headgear and hard-toed shoes are just as important, and are rapidly becoming standard equipment in all progressive mines. With some mining methods, especially underhand stoping and benching off a pilot raise under a shaft, where the driller is in some danger of falling, the safety belt should be worn. Its employment calls for certain precautions such as regular inspection and renewal of the belt and of the rope to which it is secured, the use of rope of adequate size, and tying the latter so that it will have little slack and thus avoid breaking it or injuring the wearer by a sudden stop should he fall. The service of electric cap lamps is desirable in drilling operations both for safety and efficiency. They improve lighting and ventilation and decrease the fire hazard. Many accidents are caused by poor or improper lighting; and a carbide lamp has the fault of going out at a critical time.

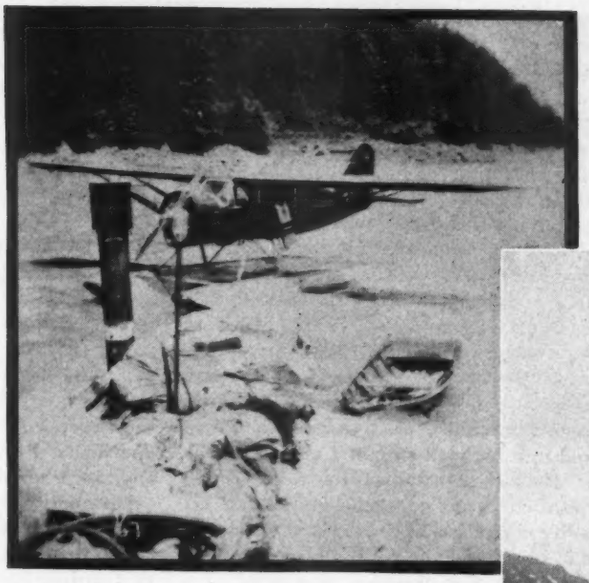
Proper care and lubrication of drilling equipment is a part of safety, even if it is an indirect one. If a drill is out of repair it means changing it for a repaired one. This results in delay, and in an endeavor to make up for lost time, an accident may occur. Keeping equipment in working order is always good practice. The better a driller's machine functions, the less likely he is to be hurt.

If a driller and his helper conscientiously drill their round they will have no time for horseplay, which is more and more being outlawed in all industries. Nevertheless, any new workmen should be reminded, before going underground, that shooting a man with compressed air is as bad as shooting him with a gun. He should also be cautioned against using compressed air for cleaning dust from his clothes, as it may enter his body.

And now a word concerning safety in steel sharpening. Accidents are preventable by application of the safe practices and devices that are usually recommended for heating, forging, grinding, and tempering operations in general. Naturally, all grinding wheels should have proper guards; the safety blocks supplied with a sharpening machine should be used for changing dies; proper facilities should be provided for efficient and safe handling of steel; and protective equipment, such as goggles, gloves, and safety shoes, should be worn.

In conclusion, I repeat that "Safety is the best policy," and I might add, "Don't take a chance—you might get hurt." Mine accident prevention, for complete success, must include certain measures to prevent drilling accidents. While the latter generally come under the head of man-failures, it must not be forgotten that they can be corrected by aggressive educational efforts. New drill helpers should be shown how to do their work the proper way, emphasizing that it is also the safe way: older drillers should be earnestly requested to give the newcomers a hand, and always set them a good example.

In many mines the men, including the drillers, are safer at work than they are in their own homes, or on the streets and highways. The industry has made remarkable progress in accident prevention—in fact, it has made contributions to safety that have been adopted by other industries. Prevention of drilling accidents goes a long way towards the creation of a "safety conscience," with the consequent performance of other operations with safety and improvement in the record of the individual worker and mining as a whole.



ABOUT TO LOAD

The plane (left) is about to take aboard the parts of a dismantled Airplane Drill for delivery to a remote section in British Columbia. The packaged pieces are discharged from the plane by a chute that insures their clearing the pontoons. If there are snowbanks on the ground the pilot tries to land them there, but the pieces are wrapped to prevent breakage.

MECHANIZING THE PLACER PROSPECTOR

Henry W. Young

RIGS AT WORK

These pictures were taken along Alaskan rivers. In each instance, the drill was delivered by "dropped parcel post."

NEW order, world barter theories, being "off the gold standard," and other revolutionary trends have not devaluated gold in the minds of men. Whenever an invader smashes into a country, the first thing he does is to lay his hands on all the gold in sight: every about-to-be-invaded country makes all speed to put its gold in safekeeping. The quest for gold still goes on in all parts of the globe not actually in the throes of war, for it is still the one thing on earth ideally suited to serve as the unit of measurement of values.

Engaged in this search for the precious mineral are both large- and small-scale operators, and it is with the latter, the placer prospector, that we are concerned. He may be in some pocketed valley high up in the Andes; in the steaming jungles of South America, India, or of the South Seas; in the frozen tundras of the Northland; or under the tidewaters of the Alaskan shore. Regardless of the location, the thrill of discovering gold is the same: it hasn't lessened a bit since the 1849 rush. The proving and exploration of a find, however, have been put on a wholly different basis in recent years, thanks to what is known as the Airplane Drill. It is so named because it can be dropped into inaccessible places from a plane. It is a mechanical explorer that multiplies a hundredfold the work a lone prospector can accomplish. With it he can test a deposit thoroughly; and, if the latter is rich enough to warrant development, it enables him to bring back accurate information with which to interest capital. Formerly he could sample the ground only by digging test pits—a laborious job that takes months and even years. At that he could not do it so well as now, and, with only meager data to offer, he had a difficult time getting hardheaded business or mining men to put up the money required for a dredging outfit.

In these days, the prospector, whether he is out on his own or for a mining company, returns to civilization as soon as he finds placer ground that shows gold upon panning. From the nearest telegraph or post office he transmits a message, and then he goes back to his discovery. In due time he hears the drone of an airplane and shortly sights it overhead, the pilot having located the area from instructions in the message. The prospector signals frantically, and when the pilot spots him the plane begins to circle overhead. There is no place to land; and before long, packages begin thudding down from a height of several hundred feet. None of these is more than 6 or 8 feet long, nor heavier than 150 pounds. Neither are there any projections on them that might catch the pilot's clothing and drag him from his plane.

These packages contain all the parts of a complete drilling rig—frame. derrick, casing, cable, drills and other tools—as well as some drums of gasoline for the 3-hp. engine that operates it. None is too heavy to be carried by plane, dog sled, mule back, or even by men, for these means of transportation are often employed instead of planes. Complete instructions for assembling and running the drill are included, and they are so simple that a person without special mechanical training can follow them and get to work in a few hours. One man can put it together and operate it in a pinch; but if he has a partner, or even two of them, so much the better

When set up, lengths of 4-inch steel casing with a 5¼-inch drive shoe at the lowermost end are driven into the ground one above another and connected with couplings. At regular intervals, a churn drill is put down and the core broken up and pulverized. Then the drill is withdrawn and a sand pump is lowered. This is a cylinder with a suction valve on top and a retaining valve on the bottom. A jerk on the sand line and the pump cylinder, having a capacity of 1 cubic foot, is filled. That done the pump is brought to the surface, its contents are dumped into a box, and it is flushed out until every bit of material is removed. The latter is then washed and the gold recovered with a simple rocker. This goes on at stated depth intervals until bedrock is reached, the gold content of each sample being entered in a logbook supplied with the drill rig. By means of tables, the value of the deposit adjacent to each sample can be readily computed in dollars and cents per cubic yard; and the gold is also classified as very fine, fine, medium, or coarse.

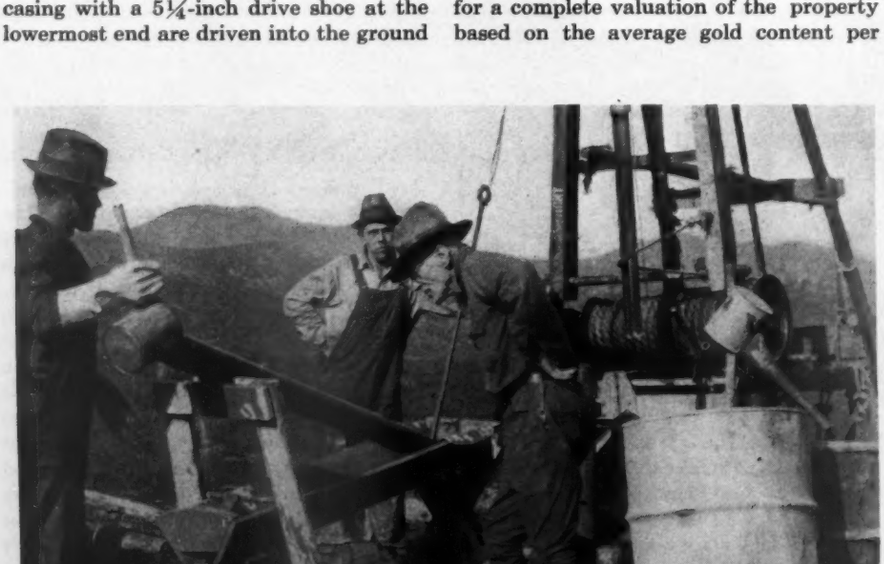
So much for one hole; but many holes are required to survey the property. The rig is changed slightly so the casing can be extracted by power. By the aid of a winch and cable, also power operated, the rig is made to pull itself to the next site without dismantling. When in position, the process is repeated. As many holes as are necessary to cover the gravel area are drilled at regular intervals in rows. Hundreds of drill samples are taken, and the quantity of gold in each, together with the depth at which it was found, are entered in the log and credited to the proper hole, each of which is numbered. When this has been done, the facts are at hand for a complete valuation of the property based on the average gold content per cubic yard. The kind of material to be handled, the total yardage, the rough contour of the bedrock, etc., also are known.

From the data thus accumulated and by observation of the terrain, the prospector fills out a report form of half a dozen pages on which there are no less than 62 general questions and many subquestions that must be answered in detail or by check mark. But when it is all completed, he really has something—a test so thorough and a picture so accurate that representatives of capital can work from it to ascertain whether or not it will be profitable to move in with heavy equipment and develop the property. In short, such a report from a competent prospector and driller forms the basis of a complete engineer's report on the property, and so can properly be termed "bankable paper."

In respect to the close correlation between drill tests and production, Charles W. Gardner states in U.S. Bureau of Mines Bulletin No. 356 that the average dredge recovery in 2,688 acres in various parts of the United States was 4 per cent greater than the values indicated by drilling. S. K. Atkinson and Murphy Brothers of Boise, Idaho, tested ground in the Idaho City Basin in 1935 with an airplane drill and obtained an indicated value of 21½ cents per cubic yard. They subsequently dredged the area and recovered 22 cents in gold per cubic yard.

First Avenue South, the "machinery row" of Seattle, Wash., is the source of the Airplane Drill—the C. Kirk Hillman Company. Kirk Hillman, manufacturer, machinery distributor and big game hunter, together with C. W. Ostrom, general manager and chief engineer, pioneered this method of scientific, look-before-you-leap gold-placer testing. The plant in which the drill is made is not particularly large as shops go, for it is a specialized business. Each outfit is, to a certain extent, made to order, and its progress is watched no matter where it goes. This is done through the medium of the prospectors and drillers. They represent a class of adventurous men it is extremely interesting to know. Some of them are old-timers that have seen the light and have "mechanized": others are scouts for big mining companies. Some are white, some are Eskimos, some natives of India—in fact, wherever gold is likely to be found you will also find the driller. Strange to say, they are letter writers and photograph takers. Among the essentials of a complete placer-test report are pictures of all the surroundings. Therefore, a voluminous correspondence from all parts of the world heads in at the Hillman offices, together with hundreds, even thousands of photographs.

The establishment has a sort of $32-an-ounce atmosphere. While machinery making and distribution is the prime business, thoughts of gold and talk of gold permeate it like a sort of theme song. Whenever a driller "comes out" he goes places. Likely



FLUSHING THE SAND PUMP

The sand pump holds exactly one cubic foot of material, and accordingly provides a convenient means of computing the value of the deposit per cubic yard. Each sample withdrawn from the test hole by the pump is discharged into a box and is then washed to recover its gold content. The pump is carefully flushed to make certain that no fine gold remains in it. Examining it here is Charles Randle, veteran driller who has sampled placer deposits in many parts of the world.

MEMENTOS FROM DRILLERS

Drill operators bring all sorts of souvenirs back with them for the Hillman factory in Seattle. C. W. Ostrom, general manager and chief engineer of the company, displays a gold-washing pan from India and some arrows from a South Sea island.

as not he ends up in Seattle, and Hillman's is where he likes to go and talk shop and get trace of distant cronies. It is a sort of adventurers' headquarters. The visitors drag in all sorts of objects—ore samples, bows, poisoned arrows, lion-tailed spears, gold-washing pans, etc.

In addition to the Airplane Drill, the company also makes the Prospector Type which weighs 4,500 pounds mounted on skids and 8,200 pounds on crawlers. It will efficiently drive 6-inch casing down 250 feet in placer testing and to a depth of 1,000 feet in well work, and also withdraw it. This machinery, too, may be flown into remote regions; but it is more frequently employed in localities which it can reach under its own power, or to which it can be hauled by truck or trailer.

In the case of most large dredging operations, scientific exploration is carried on by drill tests ahead of the dredge. Inasmuch as a large unit of this kind may cost several hundred-thousand dollars, it is plainly uneconomical to have it doing exploratory work or to use it on material below a predetermined minimum value per cubic yard. Consequently, drills are to be found in advance of a dredge like skirmishers before an army.

"Is gold getting scarcer? Will the supply eventually run out?" These questions were asked of Mr. Ostrom. "In local spots, yes," was the reply. "From the world standpoint, the surface has scarcely been scratched. Gold is probably the most universally distributed of all the precious metals, and there are vast quantities of it yet undiscovered. Nobody can possibly estimate the amount. With few exceptions, nature has made it so hard to find and so hard to recover that there is little likelihood that it will ever become a glut on the market and lose its monetary value.

"New discoveries are being made constantly. I could mention one in South America so rich that, for the time being, it is being sequestered as an actual menace to the order of the state. Also, old deposits are being worked anew by modern methods with profit. For example, before the present war put a stop to operations we were furnishing drills, mounted on large steel wheels, which went over cobblestone roads in Salonika that had been built in early Roman times. They were testing and reopening placer deposits that had been worked by slaves in those early times.

"In the state of California alone there are some 400 square miles of lava deposits, from a few feet to several hundred feet thick, that overlay many old river channels which in all probability are very rich in gold. Where recent streams have cut through the lava and exposed the gravel, values are high. It would be foolish to try to follow these beds blindly to get at the gold; but with the exploratory drill the possibilities are great.

"Placer gold, whether originally in the igneous rock in the form of particles or in quartz veins, was in the first place ground out by glaciers in many parts of the world. Then prehistoric rivers, many of them with ten times the volume of present streams, carried the gold-bearing rock downstream in what was a veritable ball mill. As the gold was separated, it sank to the bottom and remained there, provided the velocity was favorable. A pitch of about 30 feet to the mile seemed to be about right for deposition. If too steep, the gold was flushed out of the stream bed and carried on. If too flat, it was deposited with so much loose material that the concentration is low. Such, in a few words, is the history of the gold placer. Dredging operations of today, big as some of them are, represent the recovery of but a tiny bit of the richest and most accessible concentrates from those vast ore-grinding mills of ages past.

"In all parts of the world prospectors and drillers are searching and searching for gold, as men always have been. The only difference is that today they are provided with equipment that greatly multiplies the results of their efforts. They are hard men and lead hard lives, but they are interesting and likeable. It is worthy of notice that no matter where they come from, it generally turns out that they got their early training either in Alaska or California. So I say that these two places must be the original 'Mother Lodes' of all drillers. It is interesting to observe them when they come in. Fellows who have spent most of their time in the tropics seem to age faster. Men thirty-five or forty look old, often wizened. Up in Alaska, on the other hand, I know drill operators in their seventies who don't look their years and who are hale and hearty."

58 POUNDS OF NUGGETS

These two panfuls of gold, worth a small fortune, were recovered in the Livengood District in Alaska.

SAFETY IN MINING

WITH mines now stepping up production and many inexperienced men being of necessity employed, increased emphasis should be placed on safety programs. In this connection we present, in this issue, a timely article on safeguards during drilling.

Safety engineers are agreed that accidents don't just happen, they are caused. It has been found that human shortcomings are responsible for about 90 per cent of mine accidents, and that only 10 per cent are attributable to mechanical deficiencies. Repetition of those that fall in the latter group can be readily prevented by putting up guards and similar protective devices, but it is not so easy to eliminate those resulting from man-failure.

Education is the greatest single means of accident prevention. Many well-run mines impress safety upon new men before they are hired. Some even take green help through the mine when regular inspections are being made by safety engineers or the safety committee. Proper placing of workers is an important safety factor. A new man is therefore observed carefully by the shift boss and assigned to work with one or more experienced men during the breaking-in period. If he does not become safety conscious, he is not permitted to work where an unconsidered act might endanger him or others.

An effective safety measure is that of disciplining men who violate rules designed to prevent mishaps. The second offense brings a layoff of several days, and the third offense leads to dismissal. The exemplary effect of this rather drastic action on other employees is marked. First-aid training has been found to make men safety-minded. Of the principals in 277 lost-time accidents at the Bralorne Mines in Canada over a 2½-year period, only ten were first-aid men.

The wearing of hard hats and hard-toed shoes is now mandatory in most mines. Many properties also specify the use of goggles for certain types of work and issue them to the men. Objection to goggles has been largely overcome by improvements that contribute to comfort and that have given them nonfogging properties.

Careful, experienced workmen seek employment in safe mines. Mines with poor safety records have difficulty in getting this class of men and, consequently, find it hard to reduce their accident-frequency rates.

STANDARDIZATION AND THE WAR

IT HAS become a commonplace to say that the war now raging in Europe is primarily a contest between machines and the industrial organizations behind them. More unusual is the recently expressed opinion that industrial standardization may be the deciding factor in modern warfare. According to this view the downfall of France is directly attributable to her lack of standardization—her air force, in particular, having failed at a critical moment owing to the lack of replacement parts or the noninterchangeability of such parts. Germany, on the other hand, is held up as the model of organized and standardized industrial and military efficiency. In conquered territories, one of the first administrative measures of the Germans is said to be the introduction of their "DIN" codes and standards, thus permitting the immediate integration of all local industries with those of Nazidom (DIN stands for *Das ist Norm*, or this is the norm—the standard).

In Great Britain, efforts at standardization have not progressed apace; but they are now greatly accelerated by the war. So-called emergency standards are being promulgated and speedily adopted, and they cover such heterogeneous matters as the storage of explosives, precautions against air raids and incendiary bombs, and methods for salvaging tin cans or limiting their use. For instance, where formerly there were no fewer than 200 different sizes of tins for meat products alone, the number has been cut down to twenty-one. Flat tins are out completely, because they hold comparatively little. Cylindrical tins must have a diameter equal to two-thirds of their height to give the best volume to surface ratio.

One important aspect of this subject, so far as Great Britain is concerned, is the lack of common standards with the United States. A superficial view would indicate no particular problems in connection with the use by Great Britain of American-made planes, engines, machine tools, or even complete ships. After all, we use the English system of weights and measures, so why should there be any special difficulty? To begin with, there is the matter of screw threads. The British have their own standards—"Witworth," "Fine," and "Pipe": we have ours—"American Coarse" and "Fine," and "Pipe." These standards are not interchangeable. Every screw, bolt, and nut on goods made in the U.S.A. is "special" in Great Britain, and extra spares and even special wrenches must therefore be provided. In addition, the two countries have differing standards for sheet and wire gauges, and no piece of wire or sheet of any metal made in the U.S.A. can be duplicated in England. Other specific examples could be cited, but the broad fact which needs stressing is that standardization extends much further, covering, as it does, material specifications, processing methods, test codes, a great variety of things involving innumerable details in which there is a lack of conformity. Of course, all such discrepancies can be taken care of; but the necessary nonproductive diversion of effort and expenditure of time may be fatal in war.

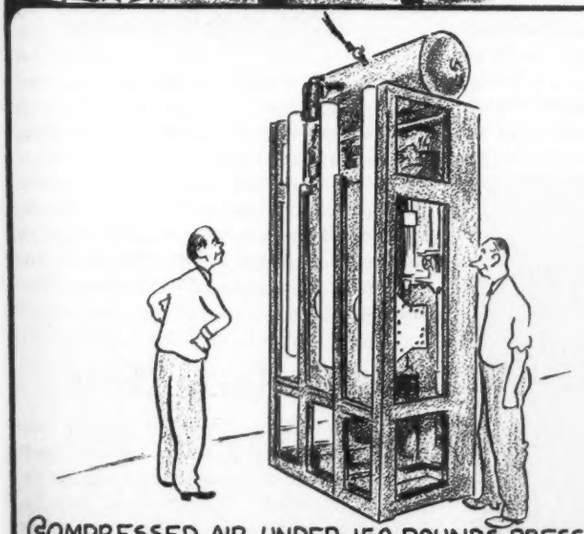
So runs the argument of the zealous standardizers. Like all purely mechanistic speculations, it overlooks fundamentals and neglects entirely the human element. But, at least, it focuses attention on a seemingly indispensable requisite for a technological civilization—that of normalizing or standardizing all industrial activities not only on a national but on a world-wide scale.

P. H.

FEATS & FACTS

By Robert Glueck

THE NEW GARAND RIFLE HAS ONLY 75 PARTS. ITS MANUFACTURE REQUIRES 1500 OPERATIONS, 900 OF WHICH CALL FOR MACHINING. THE RIFLE CONTAINS 19 VARIETIES OF STEEL. ITS INVENTOR, JOHN C. GARAND, GAVE THE DESIGN TO THE UNITED STATES; HE RECEIVES NO ROYALTIES OR OTHER COMPENSATION FROM IT.

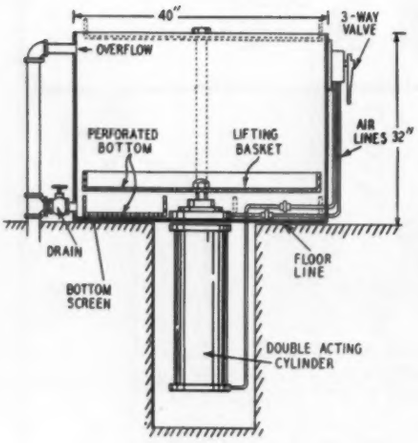


COMPRESSED AIR UNDER 150 POUNDS PRESSURE, MOVING AT A SPEED OF 600 MILES AN HOUR, EXTINGUISHED, IN 1.01 SECONDS, AN ELECTRIC ARC OF 1,500,000 KILOVOLT-AMPERES — POWERFUL ENOUGH TO LIGHT ALL THE LAMPS IN CHICAGO FOR ONE MINUTE. THE TEST REPRESENTED THE GREATEST AMOUNT OF CURRENT EVER INTERRUPTED BY A 15,000-VOLT AIR-OPERATED CIRCUIT BREAKER.

ON THE CONSTRUCTION OF THE NEW QUEEN ELIZABETH WAY BETWEEN FORT ERIE and TORONTO, CANADA, THE ROAD WAS 'BLASTED DOWN' TO SOLID GROUND IN SWAMPY SECTIONS. A LAYER OF FILL AS DEEP AS THE UNDERLYING MUSKEG WAS SPREAD ON TOP OF THE GROUND. THEN DYNAMITE WAS PLACED and EXPLODED IN SUCH A MANNER AS TO BLOW THE MUSKEG OUT FROM UNDER THE FILL AND ALLOW IT TO SETTLE IN THE EXCAVATED SPACE. THE PRESSURE OF THE MUSKEG FROM EITHER SIDE HELD THE FILL IN PLACE.

ENGINEERS, LTD., BUILT AN OIL PIPE LINE THROUGH THE PESTILENTIAL JUNGLE SWAMPS AND MOUNTAINS OF COLOMBIA IN 17 MONTHS. ALTHOUGH TYPHOID, MALARIA, DYSENTERY, YELLOW FEVER AND HEAT HAD TO BE COMBATED AT EVERY TURN, THE 500 WORKERS RETURNED TO THE UNITED STATES IN BETTER HEALTH THAN WHEN THEY LEFT. SANITATION FACILITIES WERE IN CHARGE OF A YOUNG SANITARY ENGINEER AND TEN ASSISTANTS. THE CONTRACTORS CARRIED THEIR OWN PORTABLE LIGHTING PLANT, SHOWER BATHS, WATER PURIFICATION PLANT AND HOSPITAL TRAILER.

AIR-OPERATED QUENCH TANK

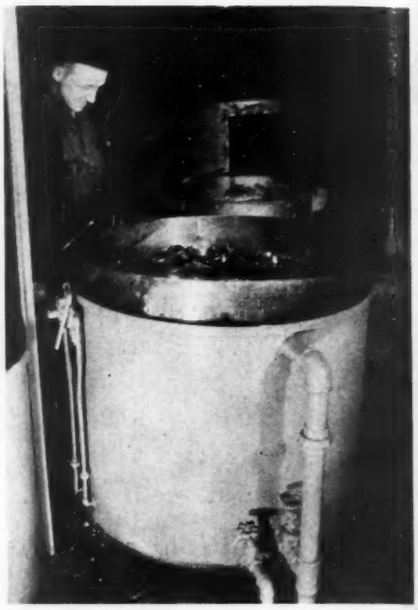


CONSTRUCTION OF TANK

FOR use in its own plant, the Lindberg Engineering Company, manufacturer of heat-treating equipment, has devised a quench tank that is easy to operate and to drain and that does away with the need of overhead lifting tackle for moving the materials undergoing treatment up and down in the oil or water. In most plants, small or light pieces are placed in a basket, and the whole is agitated manually by means of tongs. Heavier work is agitated by suspending the basket from an overhead chain hoist. A screen in the bottom of the tank is raised periodically to retrieve pieces that have fallen out of the basket.

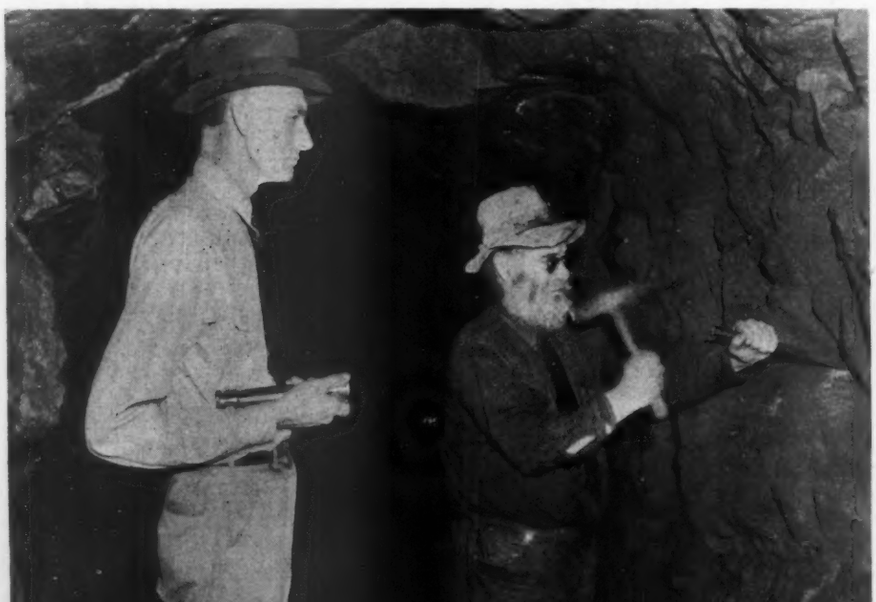
The improved equipment is shown in the accompanying drawing and photograph. It consists of a cylindrical tank provided with a perforated basket that is raised and lowered by a compressed-air cylinder underneath the tank. A screen that rests on the bottom of the tank serves to catch and retain foreign matter, such as scale or cyanide, which might otherwise get into the circulating system. The movement of the basket is controlled by a 3-way air valve that permits it to be elevated or lowered rapidly or slowly and to be stopped at any level. After the desired period of quenching, the operator raises the basket above the level of the oil or water and allows the work to drain before removing it.

For draining and cleaning a conventional quench tank, at least an hour of dirty, disagreeable work is required; but the new one can be drained, cleaned, and put back in service in about ten minutes. To do so, the drain valve is opened and the basket is lifted and released by taking off the one nut that holds it to the extension of the air-cylinder piston. The perforated screen in the bottom of the tank is raised and scale and other material that have collected on it are brushed off. The parts are then replaced and the tank is ready to continue its work until the next cleaning period.



TANK IN OPERATION

The air-operated quench tank can be built for from $200 to $225; and the experience of the Lindberg organization indicates that it pays for itself in a few months on the basis of convenience and time saved.



DEMONSTRATION OF HAND DRILLING

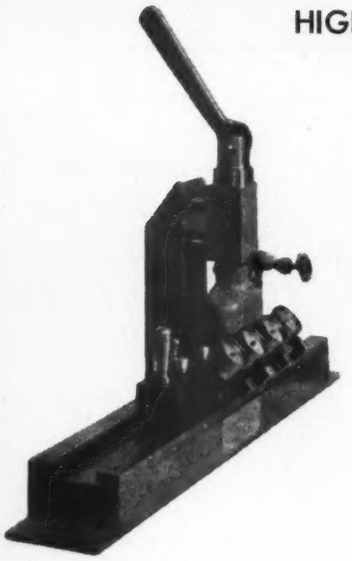
Hundreds of persons have visited the Carlton Tunnel at Cripple Creek, Colo., to witness at first hand how this drainage gallery is being driven at a pace of well over 50 feet a day. Among the callers, none has evinced greater interest than Frank E. Gimlett, a colorful character of the old mining days of the West, who styles himself the Hermit of Arbor Villa. Hale and hearty despite his 75 years, the Hermit brought along his single-jack hammer and drill steel to show the modern high-speed miners how tunnels were driven in former years. He is shown in action here, while John R. Austin, superintendent of the Carlton Tunnel, looks on.

METAL-PLATED CHINA

BY WHAT is referred to as the Metalyt Process, china can be coated with metal without destroying its inherent properties. The method was developed by a Swedish chemist, and, according to the United States attaché at Stockholm, involves covering pottery with layers of several metals having a total thickness of from 0.3 to 0.5 millimeter (approximately 0.01 to 0.02 inch). The plating, which becomes chemically united with the basic material, is only on the outside, and consists mostly of chrome because it eliminates the need of polishing. However, gold, silver, bronze, nickel, and other metals are suitable for the purpose.

So far the process has been used mainly on restaurant china to lessen breakage; and it is said that the handles of such coffee and teapots, even when not insulated, remain cold when filled with steaming beverages. Additional applications include laboratory glass, earthenware slabs or tiles, and sculptures of clay, plaster, and glass. Furthermore, there is the possibility that the invention may be the means of covering porcelain with a conducting metal, in which case it would be of considerable value to the electrical industry.

HIGH-PRESSURE AIR USED IN TESTING SHELL FUSES



FOR testing certain types of shell fuses there has been developed an apparatus that handles large numbers of them speedily and is designed for use by women operatives. The fuse in question has a recessed nose into which is fitted a copper plate or sealing disk the edge of which is coated with a shellac cement. The fuse is rolled or spun on to the plate to effect a rupture-proof seal, about which there must be no question. To determine its tightness, each fuse goes to a B.E.N. Patents, Ltd., tester which subjects it externally to air at high pressure, or a maximum pressure of 30 atmospheres—440 pounds per square inch.

The machine, according to a British source, consists essentially of a cam-operated vertical column or spindle, and of a pressure head with a hand-wheel valve mounted on the spindle. The pressure head is connected to an air receiver by means of a special flexible hose and is equipped with one or more internally coned sealing rings with a taper corresponding to that of the fuse cap so that when the lever is pulled down the rings make intimate contact with the nose of the fuse and assure an airtight seal.

The bed of the testing machine is arranged to take a sliding magazine holding two, four, or six fuses, and for each one carried there is an independent relief valve and a large-scale pressure gauge. The latter are inclined at an angle that permits easy reading by the operator. Loading and unloading of the magazine is done by an assistant, each fuse being placed on a composition locating ring that makes an air-tight seal when pressure is applied. The head can be built to test one or two fuses of the same size at one stroke. Our illustration shows a hand-operated, duplex, bench-type unit with a 4-fuse magazine. Machines worked with foot pedals also are available in single and duplex models and with one or more magazines.

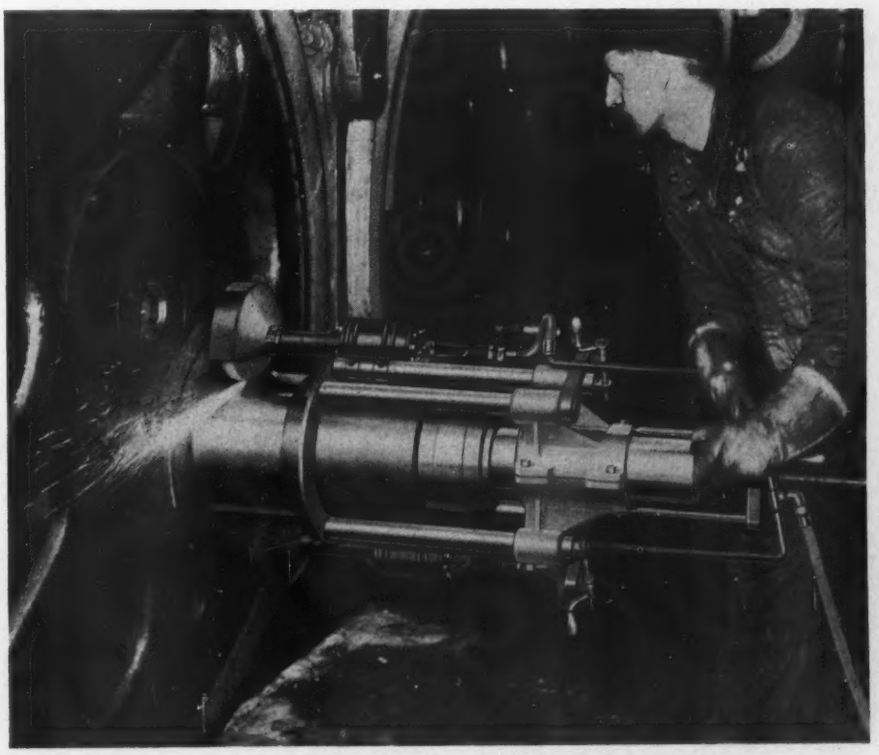
WASTE CONVERTED INTO ROADBUILDING MATERIAL

IN BUILDING asphalt roads it is the practice to dry the aggregates and to lay them on a dry bottom to assure a firm bond with the asphalt and a surface that will stand up under the pounding of traffic. It is therefore of interest to learn that by treating the stone-and-gravel mix with a new material called Kotal it can be used either wet or dry with satisfactory results. At least, those are the claims made for it by the Asphalt Treatment Corporation.

Kotal is the product of an industrial waste, and has been tested by the National Crushed Stone Association. According to the latter's findings, wet aggregates treated with it were superior to standard amiesite mixes made with dry stone. For the purpose of more conclusive tests, eighteen experimental road strips have been laid in eight states to determine the effect of winter and spring thaws on kotalized asphalt roads. At the present time the mixing material costs from twelve to sixteen cents per ton, or from nine to thirteen cents less than it costs to dry a ton of stone and gravel.

STONE CASTINGS

AFTER several years of intensive research, reports U.S. Consul J.C. Hudson in *Mineral Trade Notes*, a plant in Germany has begun the production of cast and tempered basalt as a substitute for steel plates. There, crushed and graded basalt stones are fed into large furnaces and fused at temperatures only slightly higher than the melting point of iron. The operation is continuous and the casting process is similar to that of steel. However, to avoid castings of extreme brittleness, the white-hot molds have to pass through a number of tempering kilns in the last one of which they remain 56 hours. As a result of this protracted treatment, the basalt acquires a very dense, needle-like, crystalline structure. The material is said to withstand wear better than most known products, to have a resistance to pressure close to that of iron, and a tensile strength about the same as that of glass. It is used chiefly for lining bunkers, chutes, troughs, ore-, coke-, and coal-handling equipment, ash pipes, etc., that are exposed to a high degree of abrasion.



KEEPS CRANKPINS ROUND AND TRUE

To expedite one phase of locomotive maintenance, which is more vital than ever with present-day high-speed passenger and freight trains, the Goetz-Voss Corporation has introduced the portable crankpin and journal grinder shown here. The machine does both grinding and polishing without handwork and without dropping wheels or removing guides or other parts. It is suitable for all types and sizes of crankpins, to which it is attached by the aid of a centering adapter and firmly locked, the feed being regulated to any desired depth through a feed screw. The unit illustrated is equipped for pneumatic drive and carries two grinders operated with compressed air at from 90 to 100 pounds pressure.

Industrial Notes

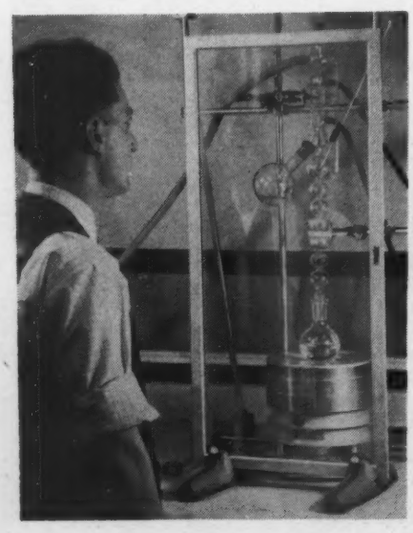
Manufacturers with paint problems can avail themselves, free of charge, of the services of a staff of 32 trained men in the Industrial Paint Clinic founded in Chicago, Ill., by the American Marietta Company.

Azure Blue is the name of a powdered chalk that serves to reveal imperfections in castings. It is mixed with water and applied by spraying. As the water evaporates, the chalk dries, the cracks showing up dark instead of light blue because they retain the moisture longer. The material is a Tamms Silica Company product.

Asphalt, asbestos, and a mineral filler are being used by Philip Carey Company to make a flooring tile named Elastite. It comes in 12x12 or 12x24-inch sizes ½ inch thick and is recommended for industrial uses where it would be of advantage to have smooth, dustless, waterproof surfaces of exceptional strength.

It is now compulsory in Belgian steel sheet, strip, and tube mills to use the regenerative pickling process invented by Paul de Lattre. It solves the serious problem of stream pollution because the spent pickling liquor, instead of being wasted, is reused continually with appreciable savings in acid consumption.

By watching his experimental apparatus from behind the shelter of a transparent shield, the laboratory worker can be safeguarded from the hazards of flying glass and liquids following an accidental explosion or broken connection. The shield is made by the Fisher Scientific Company of the latest type of laminated safety glass, which is said to be highly resistant to shock. Complete with aluminum frame, it measures 30x14 inches, and is securely mounted either vertically or horizontally in twin bases by means of setscrews. The bases hold it about an inch above the surface of the table and have a combined weight of 15 pounds which, together with the heavy shield, is normally sufficient to keep the latter upright. But should it be knocked down, the force of the explosion will be spent in the act of overturning it and the shattered test tube and contents will be checked in their flight.



Thin shim stock is now supplied by the Laminated Shim Company, Inc., in slotted cartons and plainly marked on the edge in inches—from 0 to 100, with half inch sub-divisions. The precision-thin metal can be conveniently pulled through the slot and cut off in the exact length required. Not only is waste avoided but the markings also tell when the roll is about used up, cut fingers are prevented, and handling and storage are facilitated. Rolls of brass or steel shim stock 6 inches wide and from 0.001 to 0.015 inch thick are available in these handy packages at no extra cost.

An announcement of considerable interest in the field of optics has been made by the National Research Corporation. Operating under a license, that concern is in the business of making glass such as lenses, not exceeding 16 inches in diameter, nonreflecting, incidentally preventing the loss of approximately 4 per cent of light. The process involves preparing the surface and depositing on it by distillation under vacuum a film of calcium chloride, magnesium, or other material 0.00005 inch thick. It is said that a glass so treated will transmit about 99 per cent of the light that strikes it, while a series of eight lenses will make 92 per cent of the light available.

Willson Products, Inc., has introduced a new light-weight respirator—the lightest so far approved by the U.S. Bureau of Mines. Its lightness gives the wearer increased comfort and permits the apparatus to be worn for long periods of time. It has an all-rubber facepiece that cannot be crushed out of shape, and a screw-type filter assembly that cannot be put together wrong or bent out of adjustment. The new respirator is called the Bantam.

F. J. Stokes Machine Company has developed a portable high-vacuum gauge with a range from zero to 700 microns. The instrument is placed or mounted in a horizontal position—the evacuating position—and is turned for reading into the vertical position. Means are provided that prevent the mercury from spilling and from breaking the glass by reason of the turning movement. It is claimed that the gauge enables single readings to be taken very quickly and that each of a series of successive readings takes not more than ten seconds.

We all know that greasing the rails makes for easier downhill travel; but greasing the flanges, according to recent experiments, increases a train's tractive power in climbing a curving grade. The Denver & Salt Lake Railroad has placed fourteen mechanical lubricators along a sinuous 45½-mile stretch of track that terminates at the east portal of the Moffat Tunnel and that has a total rise of 3,775 feet in 40 miles. Tests made before and after the units were put in service established the fact that curve resistance was reduced about 50 per cent and that the normal tonnage hauled could be increased by 2.6 per cent.

A new automotive gearshift which permits instantaneous speed changes without belt shifting is offered by the Lima Electric Motor Company for use with lathes, milling machines, jointers, planers, drill presses, grinders, etc., that necessitate such changes in their operation. The gearshift is designed to give three speeds forward and one reverse, or four speeds forward, and in reverse with the aid of a switch. It is built either as an integral part of the motor or as a drive that can be used with any standard motor; and by eliminating countershafts and other features of central-power drive, as well as belt shifting from pulley to pulley, it is said to increase safety and considerably to boost production.